STATE OF VERMONT
AGENCY OF TRANSPORTATION

Scoping Report

FOR

Leicester BO 1445(37)

Old Jerusalem Road, TH 12, BRIDGE 4 over LEICESTER RIVER

September 12, 2017

Contents

I. Site Information

Bridge 4 is a culvert located in a rural area along Town Highway 12, Old Jerusalem Road, approximately 100 feet west of Town Highway 10, Lower Bullock Road, and approximately 0.7 miles north of the intersection with Town Highway 1, Leicester-Whiting Road. A buried cast in place concrete slab was installed over the failed culvert to supplement the load carrying capacity of the arch. The depth of cover on top of the slab is approximately 15 inches. The existing conditions were gathered from a combination of the Inspection Report and the existing Survey. See correspondence in the Appendix for more detailed information.

Roadway Classification	Local Road, TH-12, Old Jerusalem Road, Class 3, Unpaved
Culvert Type	Corrugated Metal Plate Arch
Culvert Span	28 feet
Culvert Length	78 feet
Year Culvert Built	1972
Culvert Skew	Approximately 0 degrees
Slab Span	38 feet
Slab Width	26 feet
Year Slab Built	1998
Slab Skew	Approximately 0 degrees
Ownership	Town of Leicester
County	Addison
VTrans Maintenance District	3

Need

The following is a list of the deficiencies of Bridge 4 and TH 12 in this location.

1. This culvert has a rating of 4 “Poor” and suffered significant settlement prior to the installation of the buried concrete slab in 1997-1998.

2. The culvert does not meet the Bank Full Width determined by ANR.

3. The horizontal alignment of TH 12 and the associated guardrail is substandard.

4. The culvert is structurally inadequate, with signs of deep scour and undermining.

Existing Conditions

The arch has approximately 20 inches of deformation along its midspan and displays signs of deep scour and undermining according to inspection reports of the culvert. The foundation of the arch is a log mat that is experiencing substantial settlement allowing the arch to flare outward. Approximately 4 to 5 feet above the top of the arch, a concrete slab was installed in 1998 to help alleviate the load to the arch.

The slab design, performed by VTrans in 1997, used ultimate strength design for a HS-25 live load with impact. The slab was load rated using these design plans, assuming the slab is in fair condition, for a H20 truck. Load rating provides the designer with the highest live load that can safely utilize the structure. The slab is considered structurally deficient for an HL93 truck.

Traffic

A traffic study of this site was performed by the Vermont Agency of Transportation. The traffic volumes are projected for the years 2018 and 2038.

TRAFFIC DATA	2018	2038
AADT	160	160
DHV	30	30
ADTT	15	20
%T	11.6	14.1
%D	59	59

Design Criteria

The design standards for this bridge project include:

1. AASHTO. *A Policy on Geometric Design of Highways and Streets.* Association of State Highway and Transportation Officials, Washington, DC, 2011. ("The Green Book").

2. AASHTO. *Roadside Design Guide.* Association of State Highway and Transportation Officials, Washington, DC, 2011.

3. Vermont State Standards, dated October 22, 1997. Minimum standards are based on an ADT < 400 and a design speed of 35 mph.

Design Criteria	Source	Existing Condition	Minimum Standard	Comment
Approach Lane and Shoulder Widths	VSS Table 6.3	10'/2.5' (25')	9'/2' (22')	
Bridge Lane and Shoulder Widths	VSS Table 6.3	12'/2' (28')	9'/2' (22')	
Clear Zone Distance	VSS Table 6.5		7' fill / 7' cut (1:3), 7' cut (1:4)	
Banking	VSS Section 6.12	0% at culvert location, up to 3.5% on approaches	5.8%	substandard
Speed	VSS Section 6.2	35 mph	35 mph (Design)	
Horizontal Alignment	AASHTO Green Book Table 3-9	R= 450'	R_{min} = 431' for e = 5.8%	
Vertical Grade	VSS Table 6.6	Roadway centerline slopes at 0.86%	7% (max) for level terrain	
K Values for Vertical Curves	VSS Table 6.1	155 crest/200 sag	40 crest / 50 sag	
Vertical Clearance Issues	VSS Section 6.7	None noted	14'-3" (min)	
Stopping Sight Distance	VSS Table 6.1	793'	225'	
Bicycle/Pedestrian Criteria	VSS Section 6.13	2' unpaved shoulder	2' paved shoulder	Unpaved roadway accommodates pedestrians but not bicyclists
Bridge Railing	Structures Manual Section 13.0	2 strand cable guardrail	Steel beam guardrail	Substandard
Hydraulics	VTrans Hydraulics Section	Passes Q_{25} storm event with 0.8' of freeboard. Structure spans 28'.	Pass Q_{25} storm event with 1' of freeboard. Meet Bank Full Width of 40'.	Substandard - see hydraulics section below
Structural Capacity	SM, Ch. 3.4.1	H20	Design Live Load: HL-93	Structurally Inadequate

Inspection Report Summary

Culvert Rating	4 Poor
Channel Rating	6 Satisfactory

From the most recent Inspector's Report:

"9/23/2015 This structure has previous settlement due to deep scour and possible undermining. A buried slab unit was put in place to help spread out loading. A new structure should be installed to allow for a better hydraulic opening. JWW/JDM"

"11/20/2013 – Buried concrete slab over deformed arch culvert. When the arch completely fails someday, it will need full replacement due resulting restricted water flow. Until then however, the added slab is adequate to supplement load carrying capacity. Removed from 12 month frequency. – MJ/JS"

"07/20/2011 – Buried slab was installed in 1998 to compensate for deteriorated arch culvert. Not visible for inspection. – MJ/DK"

"4/30/09 The culvert has basically failed and would be closed if it weren't for a concrete slab cast in place above the culvert. The slab is hidden from view from the road way fill. The slab could settle if the culvert should fail. DCP"

From the Inspection Report on September 18, 2001:

"Access was gained by use of chest waders, walking along the multiple transverse pine logs, which the arch is founded on. Arch plates are covered with heavy rust scale and have areas of blistering. No holes were found through the plating at this time. The arch has extreme deformation. There is approximately twenty four inches of reversal at its mid length. Distortion along the arch is due to crushing and settlement of the log foundation. When the arch was installed the logs were laid flat. Now many are on steep incline, suggesting substantial crushing and/or settlement allowing the arch to flare outward at the spring line."

Hydraulics

A Preliminary Hydraulics Report was prepared for this project and can be seen in the Appendix. It has been determined that the existing pipe arch does not meet the Hydraulic Standard or Bank Full Width (BFW) in a free discharge condition (which assumes no tailwater from Otter Creek).

Several watershed features influence the hydraulic conditions at this project. One is the fact that the Leicester River originates at the outlet of Lake Dunmore. The lake discharges into the river in an outlet-control condition into a large complex wetland area about 6 miles upstream of the project. Another unusual feature is a small branch of the river that splits off the main flow and discharges to the Otter Creek approximately a half mile downstream of the river discharge. A significant feature is the influence of the Otter Creek. Under most joint probability model runs of the Leicester River, the water surface elevations at the project site are controlled by tailwater form the Otter Creek. It should be noted that roadway overtopping begins at relatively small events, the $Q_{2.33}$ or less, which will also make replacement options difficult to analyze.

The Preliminary Hydraulics Report states that using the State ANR equilibrium model results in a BFW of 62', but observations at the site indicate that the BFW is 30'- 40'. The Federal Emergency Management Agency (FEMA) has indicated to ANR that future emergency funds are jeopardized if BFW is not met. The ANR River Management Engineer has made a recommendation of 40'. ANR is currently in discussions with FEMA in search of accommodations for unusual hydraulic circumstances such as these.

A National Flood Insurance Program Flood Insurance Study has not been done for this area of the Leicester River, but the project and upstream reaches are within flood plains. Under typical conditions, no rise in upstream water surface elevations at the 100 year event is allowed within mapped flood plains.

Several scenarios were considered during the preliminary hydraulics study. No rehabilitation alternatives were considered in this study.

- A natural condition was modelled where the roadway and culvert is assumed to not exist. The purpose of this run was to determine the flow characteristics without culvert influence.
- An imaginary condition was modelled to ascertain whether the culvert would be capable of passing the design flow of Q_{25} without the tailwater influence. This is the most conservative scenario, but has a low probability of occurring. Freeboard at the Q_{25} flow is 0.8', which is short of the 1.0' required by the standard.
- Several different size and shape structures were reviewed to guide the selection of replacement structures.

  The first configuration modelled was a frame with a 55' span and a height of slightly over 10'. This shape produced a 5.2' freeboard and meets BFW. This shape would probably be most effectively achieved by a bridge rather than a buried structure.

  The second configuration modelled a scenario where the existing slab would be kept in service and the failing arch removed and replaced with a new open bottom structure that spans 31.4' and is 10.7' tall. This shape provides 5.1' of freeboard, results in a decrease in water surface elevations at Q_{100}, but does not span the assumed BFW of 40'. Since the level of difficulty in replacing the culvert without disturbing the slab is assumed to be very high, this configuration was not considered further.

  The third configuration models a box with a 20' span and 10' height. This meets the hydraulic standard but not the BFW, and causes an increase in the Q_{100} water surface elevation of 0.5'.

  Lastly, a 28' span frame was modelled in search of a configuration that does not raise the Q_{100} water surface elevations. The height given is vague but believed to be approximately 10'. This configuration meets the hydraulic standard but not BFW. It does not result in an increase to the Q_{100} water surface elevations.

Other scenarios may be considered with input from the Hydraulics Section.

Utilities

Underground:

There are no buried water, wastewater, or stormwater utilities near the site.

Aerial:

There are two overhead utility lines passing over and around the outlet end of the culvert. These include a communications line owned by FairPoint Communications and a fiber optic line owned by Comcast. It is not anticipated that these utilities will be relocated for the duration of the project.

Right of Way

The existing Right of Way (ROW) is shown on the Layout Sheet. At the project site, the ROW appears to be 3 rods, but doesn't include the end sections of Bridge 4. Any proposed work would require ROW on both the inlet and outlet ends of the culvert. Additional ROW will be required for all options considered except the No Action, stabilization, and strategic disinvestment alternatives.

Resources

The resources present at this project are shown on the Resource Site Plan, and are as follows:

Biological:

The culvert is located just above the confluence of the Leicester River and the Otter Creek. The project site is in a riparian area so the movement of smaller mammals, amphibians, and reptiles will need to be considered. This watercourse is regulated by the US Army Corps of Engineers and ANR.

Wetlands

Wetlands were identified in all of the quadrants surrounding the project site except for the northwest quadrant, which appears to be previously filled land. The southeast quadrant of the project site has been put into the wetland reserve program by the National Resource Conservation Service.

Rare, Threatened and Endangered Species

The project area has been identified as habitat for the freshwater mussel and the blue spotted salamander, both on the Species of Greatest Concern list. The area has also been identified as potential habitat for the Northern Long Eared Bat.

Agricultural

Winooski very fine sandy loam, a prime agricultural soil, has been located within the project area.

Archaeological:

Input from the VTrans Archaeologist identifies the project area as highly sensitive for precontact Native American presence. The project area is also in close proximity to the Elhanan Winchester Estey Property, where visible structural elements were surveyed in the 1970s. Phase I testing will be required if any work would be done outside the current culvert footprint. The locations of these archaeological sensitive areas are located on maps attached in the appendix.

Historic:
There are no historically significant resources identified at the project site.

Hazardous Materials:
According to the ANR Vermont Hazardous Sites List, there are no known active hazardous sites in the project area.

Stormwater:
There are no known stormwater concerns for this project.

II. Safety

The existing roadway has substandard banking, however, this is not addressed in the proposed alternatives. The project area does not have any crash data available. The existing guardrail, a two-strand cable rail with bent posts and loose cables, is substandard. Complete replacement of the guardrail is recommended for every alternative.

III. Alternatives

The existing roadway has substandard banking and guardrail at the project location. The banking will not be improved but replacement of the guardrail is recommended. The hydraulic standard is not met in all situations and meeting this standard may not be feasible in the suggested alternatives. The culvert is failing and stability of the arch, as well as the bearing material for the concrete slab, are of concern.

Structure Rehabilitation

Rehabilitation of the existing structure is always considered for culvert projects due to economic considerations and minimizing impacts, as well as a quick, shorter term solution to prevent the continued decline of the structural integrity.

Pipe rehabilitation options considered:

a: Pipe Liner
b: Cured In Place Pipe
c: Spray-on Lining

These rehabilitation options would employ the use of hydroblasting or hydrodemolition to clean the existing pipe interior prior to rehabilitation. In addition to cleaning, grouting will be needed to plug holes in the pipe and fill all voids on the outside of the pipe. A concrete base slab would need to be poured to ensure a stable foundation as the existing log mat is displaced, potentially due to settlement of the structure. The project site would need to be dewatered and the flow from the Leicester River rerouted to the Otter Creek in order to complete installation and allow for a curing period in dry conditions, usually about 24 hours. A service life of approximately 30 years can be expected if the pipe is rehabilitated.

Any of these repair alternatives would address the structural deficiency of the existing culvert arch with minimal interruption to the surrounding area. Traffic flow on TH 12 would be largely uninterrupted. One of the disadvantages of these repair options is the required decrease in the culvert diameter, increasing the flood elevations in the flood plains for the Leicester River and Otter Creek. Aquatic organism passage will not be improved on the site with these options. Also, these rehab alternatives require dewatering of the project site, which can create a potential dangerous working environment for the contractor. The condition of the log mat foundation is unknown and dewatering could cause further settlement in the mat leading to the collapse of the arch culvert and concrete slab above.

Due to substandard hydraulic conditions and safety concerns, these rehabilitation alternatives for the existing culvert are not considered beyond this point in the report.

Reuse the Existing Reinforced Concrete Slab

This alternative would reuse the existing concrete slab while constructing new abutments and removing the surrounding fill and existing arch culvert. The existing slab would allow for 10 foot lanes with a 2 foot shoulder on the bridge excluding the space needed for guardrail. Fascia mounted guardrail would be required as it is not feasible to drive posts on the bridge. This alternative would pass the hydraulic requirement with 5.1 feet of freeboard during a Q_{25} storm, however it would not span the required BFW of 40 feet. The construction of this alternative would require a complex process to ensure the stability of the slab during construction and protect the bearing material above the arch. This could create a dangerous working environment for the contractor and would have high construction costs. Also, the current condition of the slab is unknown since it is located under 12 to 15 inches of fill.

For these reasons, this alternative is not discussed further in the report.

Structure Replacement Using Trenchless Methods

Trenchless methods, as defined in this scoping report, include jack and bore, pipe ramming, and similar methods of installing a new pipe without open excavation. A replacement of the existing culvert adjacent to the current location using these methods was considered. This is a large structure and replacement would require a pipe of equal or larger diameter since the existing arch is not hydraulically adequate. The culvert is shallow with approximately 6 feet of fill. It is unlikely that a contractor, with the equipment and expertise to make these methods of structure replacement cost competitive, is available. This method would also require a significant amount of new ROW, as well as the relocation of the Leicester River. The project site was identified as archeologically sensitive so Phase I digging would be required if any work is done outside of the current culvert footprint.

This alternative is not considered past this point in the report.

Alternative 1: No Action

This alternative would involve leaving the culvert in its current condition with no proposed improvements. Inspection reports have noted serious deformation of the arch measured at approximately 24 inches of sag near the middle of the culvert. The inspectors identified the cause of the deformation as crushing and settlement of the log foundation. These measurements were last recorded in September of 2001 so it is difficult to identify if the addition of the concrete slab stopped the settlement of the structure. The settlement of the log foundation likely occurred soon after the installation of the arch due to the consolidation of the bearing material. The culvert was rated as a 4 (poor) on the inspection reports. This rating refers to the arch and not the concrete slab as it is not visible. However, if the arch fails further, the bearing materials for the slab could be affected and the structural integrity of the culvert will be compromised. If the town decides to proceed with this alternative, movement of the slab and arch should be closely monitored. A closure would likely be required at some point if no action is taken.

Alternative 2: Stabilization of the Structure

This alternative involves applying varying methods of stabilization that will support the existing structure and prevent further degradation. The culvert is currently experiencing settlement from poor soil strength as well as possible undermining due to instability of supporting soils. Grout injections beneath the concrete slab could stabilize the bearing material under the slab. Additional measures would include scour monitoring to help determine that scour has occurred after flood events. This alternative would also include the construction of new guardrail. The Hydraulic Standard would not be met for any flow conditions with this alternative. The existing failing culvert would remain in place.

Alternative 3: Structure Replacement with a Buried Structure

This alternative involves the removal of the existing arch and concrete slab and replacing it with a new buried structure. The ANR River Management Engineer has recommended a 40 ft. BFW span to protect the Town's ability to receive emergency funding if damage occurs due to flooding.

Borings were taken at the project site to determine the appropriate foundation. Highly compressible, organic soils make up much of the soil in the project area. The Subsurface Investigation Report recommends a substructure supported on piles rather than a spread footing to prevent settlement. Right of Way will be required for this alternative.

A temporary bridge and an offsite detour are both appropriate options for traffic control at the project location. The project site was identified as archeologically sensitive so Phase I digging would be required if any work is done outside of the current culvert footprint.

Alternative 4: Structure Replacement with Integral Abutment Bridge

This alternative involves removal of the existing arch and concrete slab and construction of a new bridge. This replacement would construct the abutments beyond the existing structure to meet BFW. The project site was identified as archeologically sensitive so Phase I digging would be required if any work is done outside of the current culvert footprint. Right of Way will be required for this alternative.

Substructure type
Borings taken at the project site determined that bedrock is located at about 60 feet with soft, cohesive soils above. The Subsurface Investigation Report recommends a substructure supported on piles to avoid settlement.

Bridge Width and Rail
The current roadway width is 25 feet in the project area, which is 3 ft. wider than the standard. It is recommended that the width remains at 25 feet to match the existing roadway. Based on projected traffic volumes, a full structure replacement will require a minimum of test level 2 bridge rail, such as fascia-mounted bridge rail, in this location.

Bridge Length and Skew
The existing culvert has a span of 28 feet with no skew. If a bridge is constructed, it will need to be constructed to provide BFW, which is 40'. The new bridge would span approximately 65 feet, assuming standard slopes up to the abutments and a retaining condition at the abutments of 7'-8'. This span may be modified by choosing various abutment heights. Skew would be near zero.

Low Beam Elevation
The Preliminary Hydraulics Study included the results for an assumed structure with a 45' BFW and 1:1.5 slopes. The assumed structure had approximately 11' retaining conditions at the abutment locations, giving a waterway area of approximately 638 SF with the low beam at 346.7'. This condition gave a freeboard depth of 5.2' at the Q_{25} event. Since an integral abutment bridge would have a similar width (about 5' narrower), and the retaining condition possibly a little less than 11', a low beam elevation could be higher, possibly in the area of elevation 343 or 344. This should be confirmed in the Final Hydraulics review.

Superstructure Type
There are many options for superstructure types that would be appropriate for this alternative.

Roadway Alignment
The existing vertical alignment meets the minimum standard. Possibly, banking could be improved in the vicinity of the bridge to improve the horizontal alignment in the project area.

Maintenance of Traffic
A temporary bridge and an offsite detour are both appropriate options for traffic control at the project location.

Alternative 5: Strategic Disinvestment

Strategic disinvestment would allow for the permanent closure of the culvert. This alternative includes demolition of the existing arch and slab, along with restoring the Leicester River to its natural condition at bank full width. Erosion control matting and vegetation would be added to the sides and bottom of the channel to prevent scour and protect the new banks from erosion. Barriers and guardrail would be installed. Old Jerusalem Road would no longer be a continuous route, requiring traffic on the north side of the project to reroute through Salisbury. The project cost is included in the cost matrix and would require the least amount of maintenance and continuing costs for both the town and the state.

IV. Maintenance of Traffic

The Vermont Agency of Transportation performs some bridge and culvert projects through its Accelerated Bridge Program, which focuses on faster delivery of construction plans, permitting, and ROW, as well as faster construction of projects in the field. One practice that will help in this endeavor is closing bridges for portions of the construction period, rather than providing temporary bridges. In addition to saving money, the intention is to minimize the closure period with faster construction techniques and incentives to contractors to complete projects early. The Agency will consider the closure option on most projects where rapid reconstruction or rehabilitation is feasible. The use of prefabricated elements in new bridges will also expedite construction schedules. This can apply to decks, superstructures, substructures, and culverts. Accelerated Construction should provide enhanced safety for the workers and the travelling public while maintaining project quality. The following options have been considered:

Option 1: Off-Site Detour

This option would close the bridge and reroute traffic from the closure on TH 12, Old Jerusalem Road, class 3 unpaved, continue north to the Town of Salisbury where TH 12 becomes TH 5, Leland Road, class 3 unpaved. The detour then travels northwest on TH 17, Morgan Road, class 3 unpaved, to the intersection of TH 1, W Salisbury Road, class 2 paved. Travel southeast on TH 1 and then south on VT 7 into Leicester. From VT 7, travel west on TH 1, Leicester-Whiting Road, class 2 paved, back to TH 12, Old Jerusalem Road.

Thru distance:	0.1 miles	1 minutes
Detour distance:	11.7 miles	22 minutes
Added distance for Thru Traffic:	11.6 miles	21 minutes
End to end distance:	11.8 miles	23 minutes

The times listed assume no delays due to traffic congestion.

An alternate detour exists routing traffic to the west of the project:

Starting at the north side of the project site, continue on TH 12, Old Jerusalem Road, class 3 unpaved, into the Town of Salisbury, where TH 12 becomes TH 5, Leland Road, class 3 unpaved. Continue north on TH 5 to the intersection with TH 1, West Salisbury Road, class 2 paved. Continue west on TH 1 to the intersection of TH 1, Creek Road, class 2 paved. At the Salisbury border with the Town of Cornwall, a temporary bridge is in place to carry TH 1 across the Otter Creek. This bridge replaces the one lane covered bridge that was destroyed by fire in late 2016. In Cornwall, the detour becomes TH 3, Swamp Road, class 2 paved. From TH 3, travel south on VT 30 into Whiting to TH 1, Leicester-Whiting Road, class 2 paved. Continue on TH 1 into Leicester and travel east to TH 12.

Thru distance:	0.1 miles	1 minutes
Detour distance:	14.9 miles	25 minutes
Added distance for Thru Traffic:	14.8 miles	24 minutes

End to end distance: 15.0 miles 26 minutes

Again, no delays for congestion are included in the travel times above.

Other detour routes may be available. Access to driveways and town highways would be maintained. A map of the primary detour route can be found in the appendix.

Since this is a town-owned project, responsibility for the detour will belong to the Town. Coordination and negotiation with neighboring towns on the detour routes is encouraged to work out any details for emergency services and implement the detour successfully.

Advantages: Utilizing an off-site detour would eliminate the need to use a temporary bridge or phase construction to maintain traffic, reducing impacts to sensitive areas like wetlands, archaeological areas, and bat habitat. This would decrease the cost and amount of time required to plan and construct a project in this location. The impacts and amount of temporary ROW required to construct a project in this location would also be reduced for this option. The safety of both construction workers and the travelling public will be improved by removing traffic from the construction site. Typically the Town's share of the project costs is reduced by 50% when detours are allowed during the construction period.

Disadvantages: Traffic flow would not be maintained through the project corridor during construction.

Option 2: Phased Construction

Phased construction is the maintenance of one lane of alternating traffic on the existing bridge while building one lane at a time of the proposed structure. Once the first half of the project is completed, traffic is shifted to the new lane, and work proceeds on the second lane. This allows keeping the road open during construction, while having minimal impacts to resources and adjacent property owners.

Existing conditions at this project site; traffic volumes, length of project, and existing roadway width, meet the most recent guidance for closing one lane of traffic and maintaining one lane of traffic, alternating direction, without traffic signals. Two-way traffic could be maintained at the project site with some temporary fill to widen the roadway. However, the existing concrete slab presents some challenges to phased construction. The stability of the culvert without the slab is unknown so traffic would need to remain routed over the slab, allowing for only one narrow lane of traffic during phasing.

Due to the possible safety concerns and complications related to phased construction on this project site, as well as the presence of a viable detour route, this traffic maintenance option is not considered further in this report.

Option 3: Temporary Bridge

Although a temporary bridge can physically be installed to maintain traffic through the corridor on this project, it would generate large impacts.

A large amount of temporary ROW would be required to construct a temporary bridge. On the upstream side of the culvert, a significant amount of fill would be required to construct the approaches in the surrounding wetland area. The southeast quadrant of the project site is also part of a wetlands reserve project of the Natural Resource Conservation Service. If the temporary bridge is placed on this land, coordination with the manager of the program will need to occur. A bridge on the downstream side of the road does not seem feasible.

Phase I testing for archaeological resources will be required if any work is done outside the existing culvert footprint. There are no environmental or historical resources present, except for the waterway itself and possibly Northern Long Eared Bat and Blue Spotted Salamander habitat, but vegetation removed from the riparian zone would need to be restored after the project.

V. Alternatives Summary

Based on the existing site conditions, culvert condition, and recommendations from hydraulics and others, the following alternatives are offered:

Alternative 1: No Action

Alternative 2: Stabilization of Structure

Alternative 3a: New Buried Structure with traffic maintained on an Off-Site Detour.

Alternative 3b: New Buried Structure with one lane alternating traffic maintained on an On-Site Detour via a Temporary Bridge.

Alternative 4: New Integral Abutment Bridge with traffic maintained on an Off-Site Detour.

Alternative 5: Strategic Disinvestment

VI. Cost Matrix[1]

Leicester BO 1445(37)		Alt 1 Do Nothing	Alt 2	Alt 3a	Alt 3b	Alt 4	Alt 5
			Stabilization	New Buried Structure	New Buried Structure	Integral Abutment Bridge	Strategic Disinvestment
			Phasing	Detour	Temp Bridge	Detour	N/A
COST[1]	Bridge Cost	$0	$100,000	$985,000	$985,000	$1,344,000	$0
	Removal of Structure	$0	$0	$50,000	$50,000	$50,000	$50,000
	Roadway	$0	$65,000	$138,000	$150,000	$155,000	$74,000
	Maintenance of Traffic	$0	$5,000	$47,000	$226,000	$49,000	$0
	Construction Costs	$0	$170,000	$1,220,000	$1, 411,000	$1,598,000	$124,000
	Construction Engineering + Contingencies	$0	$51,000	$364,000	$421,000	$480,000	$37,000
	Total Construction Costs w CEC	$0	$221,000	$1,584,000	$1,832,000	$2,078,000	$161,000
	Preliminary Engineering[2]	$0	$35,000	$234,000	$274,000	$208,000	$30,000
	Right of Way	$0	$0	$24,000	$28,000	$32,000	$5,000
	Total Project Costs	$0	$256,000	$1,842,000	$2,134,000	$2,318,000	$196,000
	Town Share	$0	2.5% $6,400	5% $92,000	10% $213,000	5% $116,000	2.5% $4,900
SCHEDULING	Project Development Duration[3]	N/A	2 years	3 years	3 years	3 years	2 years
	Construction Duration	N/A	4 weeks	10 weeks	10 weeks	10 weeks	3 weeks
	Closure Duration (If Applicable)	N/A	N/A	3 weeks	N/A	3 weeks	N/A
ENGINEERING	Typ Section - Roadway (feet)	2.5-10-10-2.5	2.5-10-10-2.5	2.5-10-10-2.5	2.5-10-10-2.5	2.5-10-10-2.5	2.5-10-10-2.5
	Typ Section - Bridge (feet)	2-12-12-2	2-12-12-2	2-12-12-2	2-12-12-2	2-12-12-2	N/A
	Geometric Design Criteria	No Change	No Change	No Change	No Change	No Change	No Change
	Traffic Safety	No Change	Improved	Improved	Improved	Improved	Improved
	Bicycle Access	No Change	No Change	No Change	No Change	No Change	N/A
	Hydraulic Performance	No Change	No Change	No Change	No Change	No Change	Improved
	Pedestrian Access	No Change	No Change	No Change	No Change	No Change	N/A
	Utility	No	No	No	No	No	No
OTHER	ROW Acquisition	No	No	Yes	Yes	Yes	No
	Road Closure	No	No	Yes	No	Yes	Yes
	Design Life	<10 years	20 years	80 years	80 years	80 years	N/A
	Annualized Project Cost	$0	$12,800	$23,000	$27,000	$29, 000	N/A

[1] Costs are estimates only, used for comparison purposes.
[2] Preliminary Engineering Costs are estimated starting from the end of the Project Definition Phase.
[3] Project Development Durations start from the end of the Project Definition Phase.

VII. Conclusion

Alternative 4 is recommended; replace the existing culvert with a new integral abutment bridge while maintaining traffic on an off-site detour. This method of traffic maintenance will allow a 10 week construction duration with a closure period of 3 weeks. The new structure will have a 65 foot span and will meet strength and geometric standards. Low beam elevation will be established in final hydraulics, but could be in the range of elevation 343-344. Final Hydraulics should confirm that the standard freeboard conditions are met, as well as avoiding an increase in the 10 year event.

The existing structure at the project site is structurally inadequate and inspection reports rate the structure as a 4 (Poor).

Replacement of this structure with a bridge offers the most advantages for this project site. This alterative meets the 40' bank full width as determined by the ANR River Management Engineer and the Hydraulic Standard as best as it can be defined for this site. The abutments will be founded on piles to prevent settlement of the structure. There is approximately 15' from stream bed to roadway surface. It is likely that cofferdams will be required to construct the abutments unless the bridge span is increased even further.

Archaeological phase I testing, as well as an investigation into wetland impacts, may be required prior to construction for this alternative.

The existing roadway geometry will not be changed at the project location, but new guardrail will be installed to meet the current safety standard.

<u>Maintenance of Traffic:</u>

The recommended method of traffic control is to close the roadway at the project site and maintain traffic on an official signed detour route. This detour will add approximately 11.7 miles (22 minutes) to the thru route. Traffic impacts due to construction are anticipated to be minimal as traffic volumes are low for the project site.

Utilizing an offsite detour will eliminate the need for a temporary bridge or phased construction. This will lower project costs by reducing the amount of materials needed and any additional right-of-way acquisition as well as limit the construction duration and effect on the public.

Because this is a Town-Owned project, the Town is responsible for choosing and signing the detour route.

Appendix A: Site Pictures

TH 12 looking south

TH 12 looking north

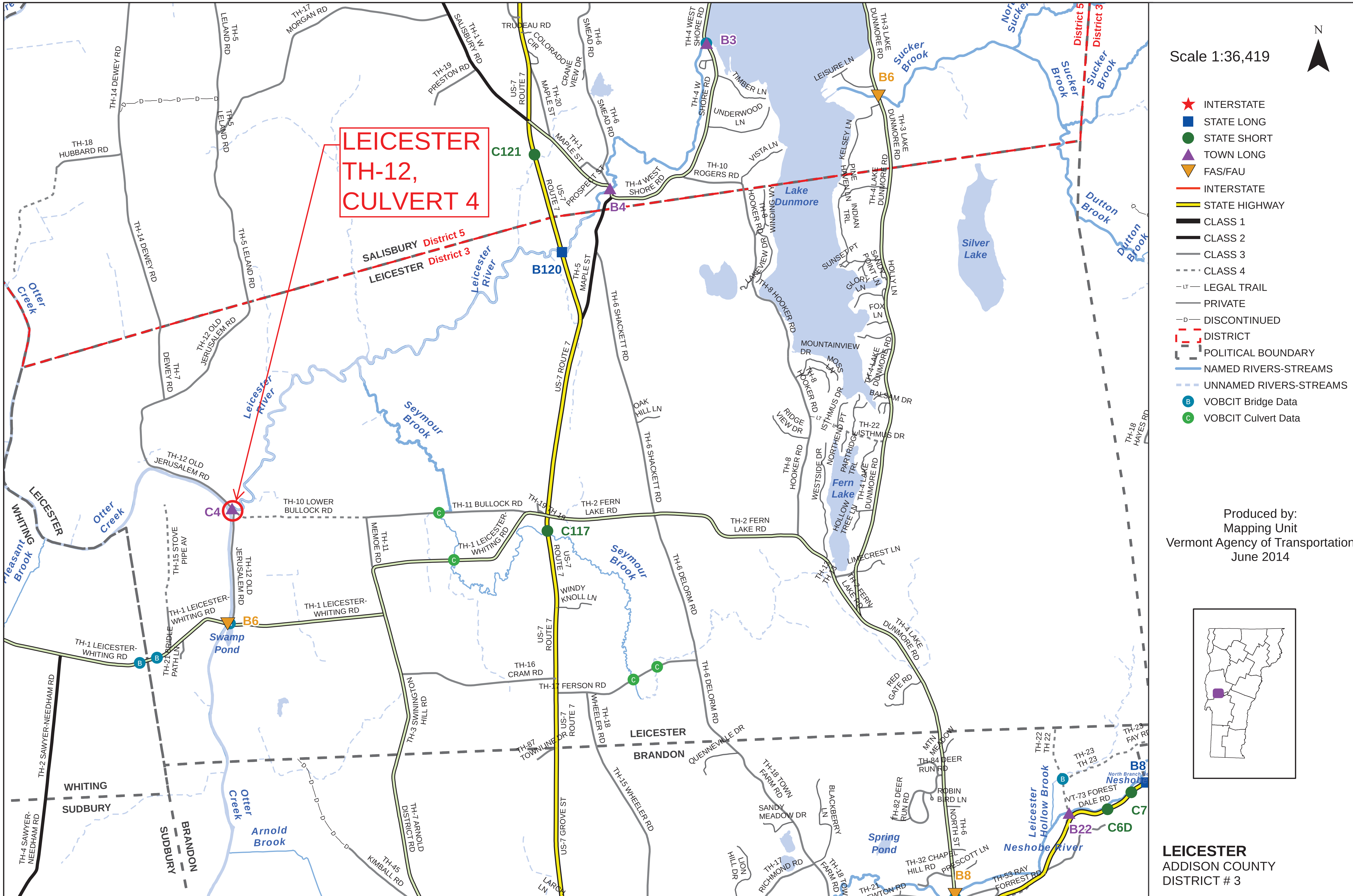

Culvert Inlet


Looking Upstream

Culvert Outlet

Looking Downstream

Appendix B: Town Map


LEICESTER
TH-12,
CULVERT 4
Scale 1:36,419
N
INTERSTATE
STATE LONG
STATE SHORT
TOWN LONG
FAS/FAU
INTERSTATE
STATE HIGHWAY
CLASS 1
CLASS 2
CLASS 3
CLASS 4
LEGAL TRAIL
PRIVATE
DISCONTINUED
DISTRICT
POLITICAL BOUNDARY
NAMED RIVERS-STREAMS
UNNAMED RIVERS-STREAMS
VOBCIT Bridge Data
VOBCIT Culvert Data
Produced by:
Mapping Unit
Vermont Agency of Transportation
June 2014
LEICESTER
ADDISON COUNTY
DISTRICT # 3
SALISBURY
LEICESTER
WHITING
BRANDON
SUDBURY
District 5
District 3
Lake Dunmore
Silver Lake
Fern Lake
Swamp Pond
Spring Pond
Leicester River
Seymour Brook
Otter Creek
Sucker Brook
Dutton Brook
Arnold Brook
Neshobe River
Leicester Hollow Brook
Pleasant Brook
C4
C117
C121
B120
B3
B4
B6
B8
B22
C6D
C7
TH-12 OLD JERUSALEM RD
TH-10 LOWER BULLOCK RD
TH-11 BULLOCK RD
TH-1 LEICESTER-WHITING RD
TH-2 FERN LAKE RD
US-7 ROUTE 7
TH-6 SHACKETT RD
TH-6 DELORM RD
TH-4 LAKE DUNMORE RD
TH-5 LELAND RD
TH-14 DEWEY RD
TH-16 CRAM RD
TH-17 FERSON RD

Appendix C: Bridge Inspection Report

STRUCTURE INSPECTION, INVENTORY and APPRAISAL SHEET

Vermont Agency of Transportation ~ Structures Section ~ Bridge Management and Inspection Unit

Inspection Report for LEICESTER | bridge no.: 00004 | District: 3

Located on: C3012 over LEICESTER RIVER | approximately 0.74 MI TO JCT W CL2 TH | Owner: 03 TOWN-OWNED

CONDITION

Deck Rating: N NOT APPLICABLE
Superstructure Rating: N NOT APPLICABLE
Substructure Rating: N NOT APPLICABLE
Channel Rating: 6 SATISFACTORY
Culvert Rating: 4 POOR
Federal Str. Number: 100109000401091
Federal Sufficiency Rating: 048.6
Deficiency Status of Structure: SD

AGE and SERVICE

Year Built: 1972 Year Reconstructed: 0000
Service On: 1 HIGHWAY
Service Under: 5 WATERWAY
Lanes On the Structure: 02
Lanes Under the Structure: 00
Bypass, Detour Length (miles): 12
ADT: 000100 % Truck ADT: 02
Year of ADT: 2007

GEOMETRIC DATA

Length of Maximum Span (ft): 0025
Structure Length (ft): 000025
Lt Curb/Sidewalk Width (ft): 0
Rt Curb/Sidewalk Width (ft): 0
Bridge Rdwy Width Curb-to-Curb (ft): 0
Deck Width Out-to-Out (ft): 0
Appr. Roadway Width (ft): 025
Skew: 11
Bridge Median: 0 NO MEDIAN
Min Vertical Clr Over (ft): 99 FT 99 IN
Feature Under: FEATURE NOT A HIGHWAY OR RAILROAD
Min Vertical Underclr (ft): 00 FT 00 IN

STRUCTURE TYPE and MATERIALS

Bridge Type: CMPPA/BURIED RC SLAB
Number of Approach Spans: 0000 Number of Main Spans: 001
Kind of Material and/or Design: 3 STEEL
Deck Structure Type: N NOT APPLICABLE
Type of Wearing Surface: N NOT APPLICABLE
Type of Membrane: N NOT APPLICABLE
Deck Protection: N NOT APPLICABLE

APPRAISAL *AS COMPARED TO FEDERAL STANDARDS

Bridge Railings: 0 DOES NOT MEET CURRENT STANDARD
Transitions: 0 DOES NOT MEET CURRENT STANDARD
Approach Guardrail: 0 DOES NOT MEET CURRENT STANDARD
Approach Guardrail Ends: 0 DOES NOT MEET CURRENT STANDARD
Structural Evaluation: 4 MEETS MINIMUM TOLERABLE CRITERIA
Deck Geometry: N NOT APPLICABLE
Underclearances Vertical and Horizontal: N NOT APPLICABLE
Waterway Adequacy: 6 OCCASIONAL OVERTOPPING OF ROADWAY WITH INSIGNIFICANT TRAFFIC DELAYS
Approach Roadway Alignment: 8 EQUAL TO DESIRABLE CRITERIA
Scour Critical Bridges: 8 STABLE FOR SCOUR

DESIGN VEHICLE, RATING, and POSTING

Load Rating Method (Inv): 0 NO RATING ANALYSIS PERFORMED
Posting Status: D OPEN, TEMPORARY SHORING
Bridge Posting: 5 NO POSTING REQUIRED
Load Posting: 10 NO LOAD POSTING SIGNS ARE NEEDED
Posted Vehicle: POSTING NOT REQUIRED
Posted Weight (tons):
Design Load: 2 H 15

INSPECTION and CROSS REFERENCE

X-Ref. Route:
Insp. Date: 092015 Insp. Freq. (months) 24 X-Ref. BrNum:

INSPECTION SUMMARY and NEEDS

9/23/2015 This structure has previous settlement due to deep scour and possible undermining. A buried slab unit was put in place to help spread out loading. A new structure should be installed to allow for a better hydraulic opening. JWW/JDM

11/20/2013 - Buried concrete slab over deformed arch culvert. When the arch completely fails someday, it will need full replacement due resulting restricted water flow. Until then however , the added slab is adequate to supplement load carrying capacity. Removed from 12 month frequency. ~ MJ/JS

07/20/2011 - Buried slab was installed in 1998 to compensate for deteriorated arch culvert. Not visible for inspection. ~ MJ/DK

4/30/09 The culvert has basically failed and would be closed if it weren't for a concrete slab cast in place above the culvert. The slab is hidden from view from the road way fill. The slab could settle if the culvert should fail. DCP

Appendix D: Preliminary Hydraulics Report

Memorandum

To: Leslie Russell
VTrans Hydraulics Project Manager

Date: November 16, 2016

Project #: 57897.00

From: Ryan Lizewski
Hydraulics Engineer (VHB)

Re: PRELIM HYDRAULICS
LEICESTER – BO 1445(37)/Culvert 4 over the LEICESTER RIVER

PROJECT HISTORY and BACKGROUND

Bridge No. 1445(37) is located on Old Jerusalem Road over the Leicester River in the Town of Leicester, approximately 50 feet upstream of the confluence with Otter Creek. There are limited record plans dated September 1972 available. The date of construction for the current culvert is believed to be approximately 1972 when the previous structure, built at an unknown date, was replaced. The structure consists of a corrugated metal open arch culvert with an open area dimension of approximately 28-ft wide and 9.6-ft high. The culvert is aligned perpendicular to Old Jerusalem Road with and out-to-out width of approximately 78-ft. According to the 1972 plans, the culvert is held in place by a 40' wide plank cut-off wall below and by granular borrow above. Based on observations from a field visit performed by VHB on 09/04/2016, the culvert is currently sagging in the middle under the weight of Old Jerusalem Road. In the early 2000s, as a short term solution to disperse loads from the roadway, a 15-in thick concrete slab, approximately 37-ft by 25-ft, was placed above of the culvert to prevent further damage to the culvert. At this location, Old Jerusalem Road is a 2-lane dirt road approximately 43-ft wide servicing many small farms and houses.

The roadway is categorized as a local road with a minimum hydraulic design flood frequency of a 4% annual exceedance probability (AEP) event (25-year flood) according to The Vermont Transportation Agency (VTrans) Hydraulic Manual, adopted May 28, 2015 (VTrans Manual). There is no National Flood Insurance Program (NFIP) Flood Insurance Study (FIS) available for Otter Creek or Leicester River at this location. The project area was surveyed in January 2016 by VTrans using English units with a NAVD 88 vertical datum.

The headwaters of Leicester River begin as an outlet from Lake Dunmore, a 985 acre lake located in Salisbury and Leicester Vermont. The Leicester River flows SW for approximately 2.3 miles before entering a large wetland system where it meanders for another 4 miles before outletting to Otter Creek. Along with the main stem of Leicester River, which passes through the culvert, a smaller perennial stream exists that carries flow from the wetland system to Otter Creek. The perennial stream outlets through a 36-inch culvert, roughly half a mile downstream of the Leicester River outlet.

The Vermont Agency of Natural Resources (VANR) bankfull geometry regression equations estimate the bankfull width (BFW) for Leicester River to be approximately 62-ft. However based on the 2016 survey and VHB's field visit, the actual field conditions within the study reach varying between 30-ft to 40-ft. The VANR bankfull width estimate for Leicester River is not applicable as it does not account for Lake Dunmore which is outlet controlled nor the existence of the second outlet to Otter Creek from the Leicester River wetland system. For this crossing, we recommend a BFW of 40-ft.

A request has been made by the Vermont Agency of Transportation (VTrans) for 2-diminsuion steady state preliminary hydraulics analysis and an evaluation of culvert replacement alternatives. The 2-dimensional analysis is appropriate for this crossing given the relatively unconfined Leicester River floodplain system upstream from the subject crossing which contains multiple outlets discharging to Otter Creek.

HYDROLOGY

VTrans provided peak flow estimates for the Leicester River to the subject crossing. The peak flow estimates for Leicester River are provided below.

Drainage Area = 37.5 square miles

STUDY VALUES (CFS)

$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}	Q_{200}
700	1,200	**1,600**	1,900	2,200	2,600

Due to the proximity of the culvert to the confluence of Otter Creek, VHB included the section of Otter Creek that abuts Old Jerusalem Road into the hydraulic analysis in order to evaluate potential tailwater effects on the hydraulic performance of the crossing. To estimate the flood flows of Otter Creek, the preferred methodology presented in the VTrans Hydraulic Manual recommends following the U.S. Geological Survey's (USGS) Bulletin 17B methodology when there is a gage with sufficient period or record on the waterway.

VHB followed the Bulletin 17B methodology and completed a Lognormal Pearson (Log-Pearson) Type III statistical analysis on annual peak discharges for two USGS stream gauges located on Otter Creek. USGS Gauge Number 04282000 is located upstream of the site in Rutland, VT. The gauge has 87 years of record data and a drainage area of approx. 307 square miles. The second gauge, USGS Gauge Number 042825000, is located downstream from the site in Middlebury, VT. The gauge has 101 years of record data and an approx. drainage area of 628 square miles. VHB used the US Army Corps of Engineer's (USACE) Hydrologic Engineering Center Statistical Software Package (HEC-SSP) to compute flood flow estimates for the various return intervals., VHB applied an area-relationship adjustment to the gauges' record data to account for the difference in drainage areas and to accurately apply them to the Leicester River site which has a drainage area of 490 square miles.

The estimated flood flows for Otter Creek at the site varied significantly between the two stream gage analyses with the upstream gage predicting higher flow estimates than the downstream gage. Based on review of aerial imagery, the variance in flood flow estimates between stream gages is likely result of several small dams and undersized crossings that fall between the two gauge locations and could account for the attenuation of flood flows moving downstream. VHB the averaged the results from the two stream gage analyses to develop the Otter Creek flows at the Leicester site. Flows for Otter Creek can be seen below.

Drainage Area = 490 square miles

STUDY VALUES (CFS)

	$Q_{1.25}$	$Q_{2.33}$	Q_{10}	Q_{20}	Q_{50}	Q_{100}	Q_{200}
Flows based on the US Rutland gauge	5,729	8,305	13,406	15,868	19,489	22,436	25,635
Flows based on the DS Middlebury gauge	3,591	5,478	5,478	6,387	7,650	8,677	9,772
Average	**4,154**	**5,948**	**9,442**	**11,142**	**13,570**	**15,556**	**17,703**

A flood event on the tributary Leicester River likely occurs as a statistically independent event compared to the main waterway (Otter Creek) due to the variance in watershed size. VHB evaluated the coincidental flood frequency occurrences for the Leicester River and Otter Creek using a joint probability analysis based on the contributing drainage areas as outlined in the VTrans Hydraulic Manual. The combination of flood event occurrences for both waterways can be found in Table 1.

Table 1: Joint Probability for a Watershed 10<Ar<100

Otter Creek AEP	Leicester River AEP
$Q_{2.33}$	$Q_{2.33}$
Q_{10}	Q_{10}
Q_{10}	Q_{25}
Q_{25}	Q_{50}
Q_{50}	Q_{100}
Q_{100}	Q_{200}

HYDRAULICS

VHB's hydraulic analysis used the Bureau of Reclamation's Sedimentation and River Hydraulics- Two Dimensional (SRH-2D) river flow model with Aquaveo's Surface-water Modeling System (SMS) as the user interface and post-processor.

Topographic Inputs: VHB blended multiple topographic and bathymetric datasets including the January 2016 field survey, 2012 1.6M Light Detection and Ranging (Lidar) data from the Vermont Center for Geographic Information (VCGI) website, record bridge plans, Geographic Information System (GIS) imagery, and visual observations to create a seamless digital elevation model. To obtain an accurate topographic geometry, VHB extracted point elevation information at 5' intervals from the Lidar dataset and removed all points within the 2016 survey area. Point elevation information from the survey was merged with the Lidar elevations and blended together at the limit of the survey extents. Along with accurate topographic geometry of the ground surface, the model needs also needs accurate bathymetric data within the channel. Lidar data collection tools do not penetrate the water surface and therefore are not representative of bathymetric elevations below the water line. These point were deleted from the topographic surface. Although record plans for the area were investigated, channel bathymetry data was not available beyond the 2016 survey extents. Therefore, to form the Otter Creek channel, VHB developed a typical five-point cross section from the 2016 survey and uniformly applied the cross sectional geometry to the length of the channel at 5-ft intervals. The cross section elevations were adjusted to follow a constant slope, which was estimated using the difference in the water surface elevations from the Lidar data. VHB then burned in the channel elevation points with the Lidar and survey elevations and blended the elevations at the various data boundaries in order to create one smooth and accurate topographic surface, which can be seen below in Figure 1.

Figure 1: Merged topography and Domain Extents

2-D Mesh Generation: To create the physical simulation inputs needed in the SRH-2D software, VHB created a 2d-mesh using the mesh generation function within the SMS user interface. VHB defined the waterways to have a patch type mesh while all other areas were defined to be paved. A patch mesh is a series of similarly shaped quadrilaterals where as a patch mesh type is a series of triangles. The differentiation of the mesh types is critical because it patch mesh aids in the computations of the flow through the mesh cells. The mesh contains small cells, apporx. widths of 8-ft, near the culverts and inlets into Otter Creek, and increasingly courser cells, as large as 390-ft, as the mesh extends outwards into the floodplain. Small cells are necessary around critical points of interest in order to obtain more computational detail and therefore more accurate results. VHB iteratively finessed the mesh in SMS using mesh element quality checks until the mesh surface had smooth transitions between the two mesh types. Such checks included having concave quadrilaterals, a minimum interior angle of 15 degrees, a maximum interior angle of 130 degrees, an element area change less than 50%, and a maximum number of eight connecting elements. The mesh was also iteratively adjusted to ensure that the topographic elevation data was accurately reflected. VHB delineated arc breaklines along important features such as roadway extents, banklines, and major elevation changes to check that all local low and high elevation points were incorporated.

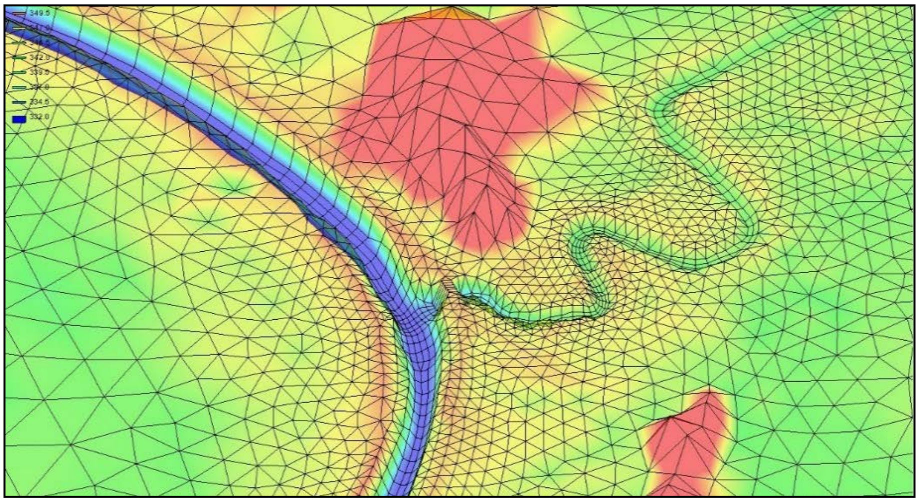


Figure 2: 3d View of the Mesh around Leicester River Culvert Crossing & River Confluence

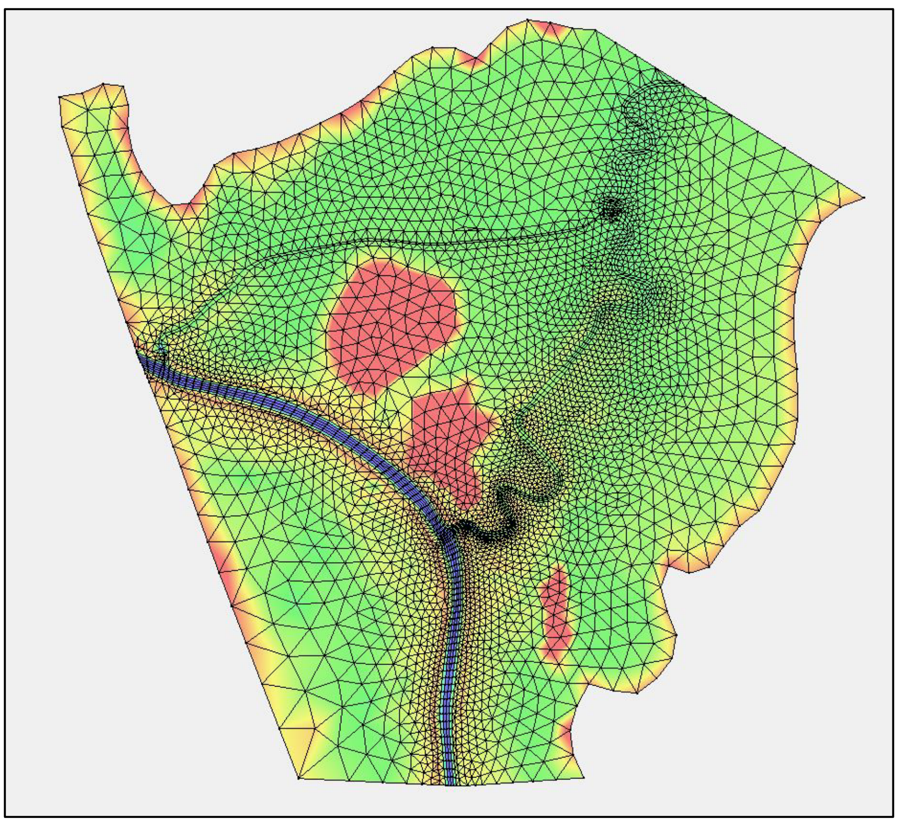


Figure 3: Mesh of Project Area

Roughness: VHB assigned roughness factors (Manning's N value) for the existing stream conditions and floodplain limits. Various landuse zones and vegetation zones were delineated out throughout the project area in order to properly assign roughness factors. Using the Materials Coverage function within the SMS user interface, six different categories were defined and assigned to all areas within the model limits; Water-Otter Creek, Water-Leicester River, Wetland, Floodplain, and Forest. Each material type had a unique Manning's N coefficient, which can be seen in Table 2 below. Note that although the area footprints of culverts remain unassigned in the materials coverage and are without a Manning's N values, the culverts get individual roughness factors assigned later on in the process.

Table 2: Materials & Manning's N coefficients

Material	Manning's N
Water- Otter Creek	0.03
Water- Leicester River	0.035
Wetland	0.04
Floodplain	0.06
Forest	0.08
Unassigned (culverts)	NA

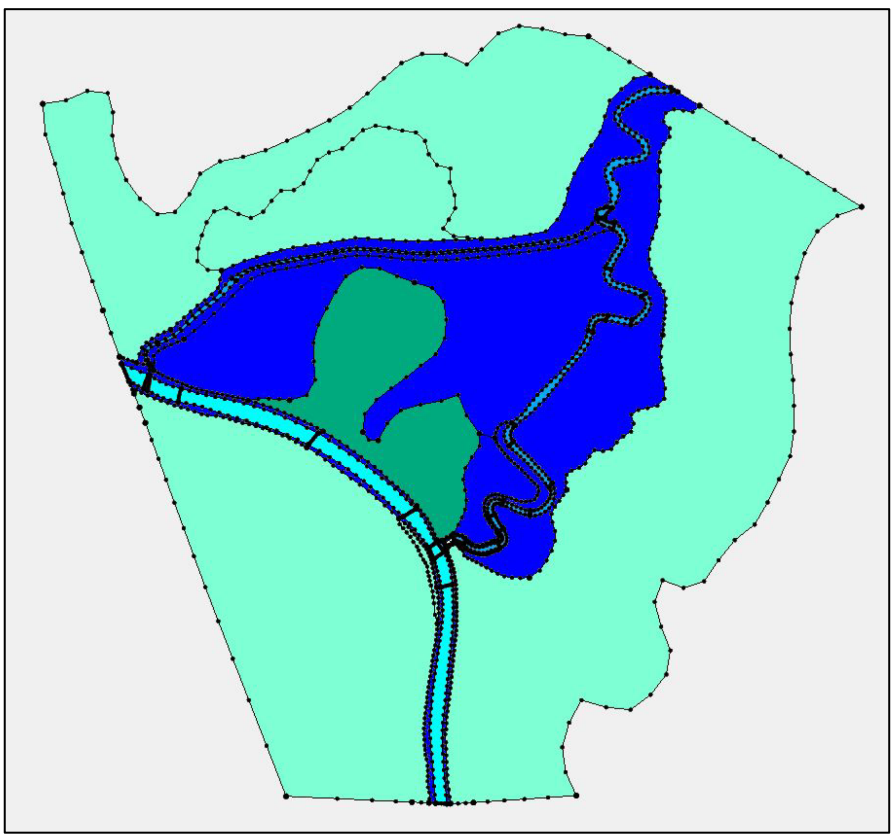


Figure 4: Material Coverage Assignments for the Project Area. Mint= Wetland, Dark Blue= Wetland, Dark Green= Forest, Cyan= Water-Otter Creek, & Light Blue = Water- Leicester River

Boundary Conditions: VHB created upstream and downstream boundary condition files for every simulation through the SMS user interface. The upstream bounds, found at the beginning of Otter Creek and Leicester River consisted of the flow for the river for that given simulation. The downstream boundary condition was the normal depth for Otter Creek, calculated for each simulation using total flow, slope, Manning's N, and the underlying topographic data. A new boundary condition had to be created for each simulation since the total flow always changed but the slope, 0.008% calculated using Lidar, the roughness coefficient, 0.03 for Otter Creek, and the topo data remained the same throughout the various simulations and scenarios. Table 3 below shows the boundary condition inputs for varying simulations.

Table 3: Boundary Conditions

Leicester River	Otter Creek	Otter Creek US Boundary (cfs)	Leicester River US Boundary (cfs)	Otter Creek DS Boundary Elevation (ft)
Q25	Free Discharge	1100	1200	339.8
Q100	Free Discharge	1100	2200	342.6
Q25	Q10	9442	1600	354.9
Q100	Q50	13570	2200	360.4

Culvert Data: The boundary conditions file also stores the pertinent culvert data for each simulation. VHB set up the two culverts within the project area differently to aid the computation time of each simulation. The Leicester River culvert was assigned to use the HY-8 culvert program whereas the smaller culvert, leading from the upland wetland system and outletting to Otter Creek just downstream of the Leicester River, was assigned to use the simpler culvert data form built within the SMS user interface. The linear boundary form can be seen below in Figure 5.

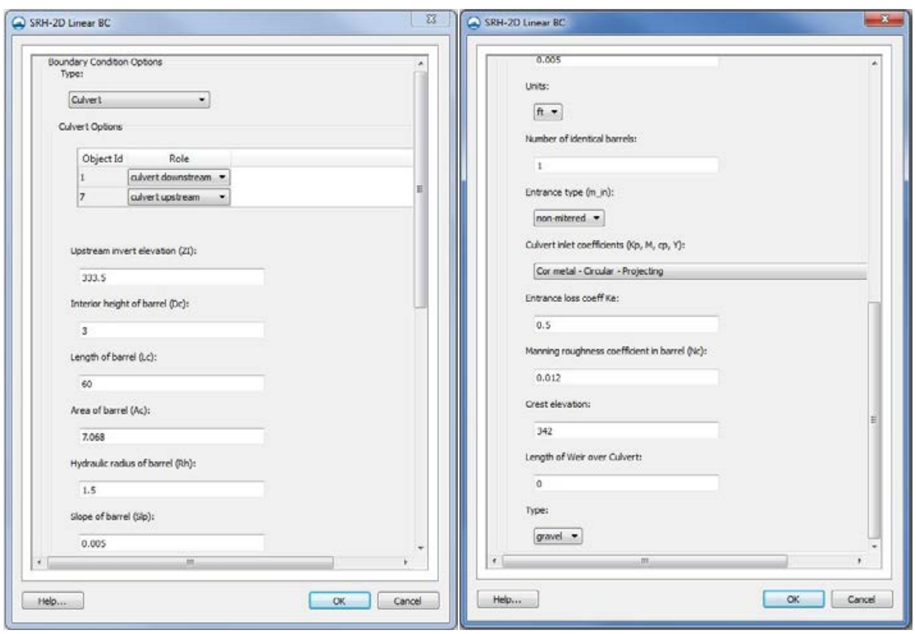


Figure 5: SMS Form for a Linear Boundary (Culvert)

RESULTS

Scenarios: A total of four model scenarios were investigated, including:

- Existing Conditions
- Natural Conditions
- Culvert Alternative 1: New culvert
- Culvert Alternative 2: Re-use existing concrete slab & New culvert
- Culvert Alternative 3: New Concrete Box Culvert

EXISTING CULVERT**:** The existing culvert is a corrugated metal, open bottom, arch culvert measuring roughly 28-ft wide and 9.8' tall with an out-to-out width of 78-ft. The hydraulic opening of the culvert is approx. 144.8-sqft with a low chord elevation of 343-ft. The existing upstream and downstream inverts are 344.9-ft and 344.7-ft, respectively.

The initial hydraulic model runs assumed the joint probability tailwater condition as previously presented in this memorandum. It quickly became evident that the flooding in this area is driven by Otter Creek based on the results from the joint probably model runs. The water surface elevation upstream of the culvert was higher than the low chord of the culvert for all flows analyzed due to backwater from Otter Creek.

VHB, after consulting with VTrans, evaluated performance of the bridge configuration over Leicester River assuming an Otter Creek bankfull tailwater condition (approx. $Q_{1.25}$) and another series of model runs assuming a free discharge scenario. Results predicted that the water surface elevations within Leicester River are significantly affected by Otter Creek even at a bankfull tailwater condition. The free discharge condition would allow us to evaluate performance of the hydraulic bridge opening based on flows from the Leicester River without influence from flood from Otter Creek. This free discharge scenario would also present the most conservative velocities through the crossing. After discussion with VTrans, the following hydraulic analysis assume a free discharge condition without any tailwater affects from Otter Creek.

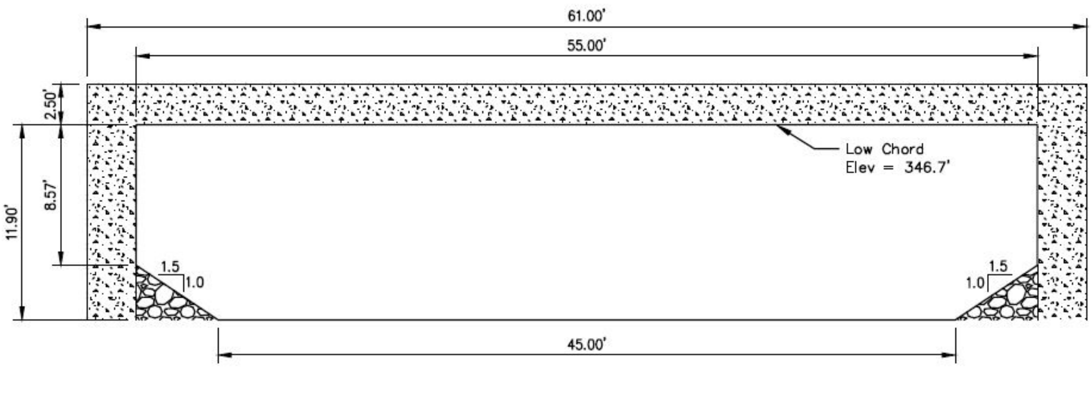
In free discharge condition, the existing culvert does not meet the VTrans hydraulic requirement to pass the Q_{25} flow with 1.0 foot of freeboard as measured to the low chord of the structure. The model predicts 0.8-ft of freeboard, as measured one culvert length upstream, with an existing low chord elevation of 343-ft (NAVD88). The existing culvert has a clear span of 28-ft and does not span the estimated BFW of 40-ft. The model predicts a water surface elevation of 343.7-ft upstream from the crossing during the Q_{100} event. Results for the design storm in the vincinty of the bridge assuming a free discharge condition can be seen below in Table 4.

NATURAL CONDITION: VHB developed a natural conditions model by removing both culverts and roadway. To remove the road, the topographic point elevations of the roadways were lowered to match the surrounding grades. This model was developed to simulate conditions through Leicester River and into Otter Creek as if there were no culverts or roadway embankment restricting river flows. The analysis predicts that the Leicester river water surface elevations would be 341.8-ft and 343.3-ft for the Q25 and Q100 flows respectively.

CULVERT ALTERNATIVES: VTrans provided three conceptual culvert scenarios to evaluate. The design storm, 4% AEP, was run with a free discharge condition for all three culvert alternatives. Full results for the design storm in a free discharge conditions for all culvert alternatives can be seen below in Table 4.

Culvert Alternative 1 – 55-ft Span

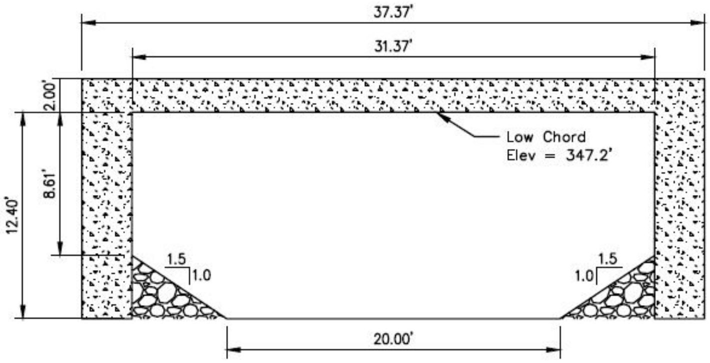
Culvert alternative 1 is a single span bridge, 55-ft wide and 10.2-ft tall. This design assumes a trapezoidal channel geometry with 1.5:1-ft channel side slopes forming natural channel banks through the crossing. No changes to the roadway width or profile is proposed. Culvert alternative 1 has the largest hydraulic opening of all the alternatives with 637.8-sqft and a low chord of 346.7-ft. This alternative maintains 5.2-ft of freeboard and meets the VTrans hydraulic requirement to pass the Q25 flow with 1.0-ft of freeboard. This option also spans the BFW of 40-ft. During the Q_{100} storm event, the water surface elevations decrease around the culvert by 1.0-ft, as compared to existing conditions, to an elevation of 342.7-ft.



CULVERT ALTERNATIVE #1: NEW CULVERT

Culvert Alternative 2 – 31.4-ft Span (Reuse Concrete Slab):

This alternative reuses the existing concrete slab located above the center of the existing culvert and replaces the existing culvert with a new open bottom structure, 31.4-ft wide and 10.7-ft tall. Like Alternative 1, this design assumes a trapezoidal channel geometry with 1.5:1 channel side slopes within the culvert area. No changes to the roadway width or profile is proposed. Alternative two has a hydraulic opening of approx. 367.4-sqft with a low chord elevation 347.2-ft. This alternative has 5.1-ft of freeboard and meets the VTrans hydraulic requirement to pass the Q25 flow with 1.0-ft of freeboard. This option does not spans the BFW of 40-ft. In the Q_{100} storm event, the water surface elevations decrease around the culvert by 0.2-ft, as compared to existing conditions, to an elevation of 343.5-ft.

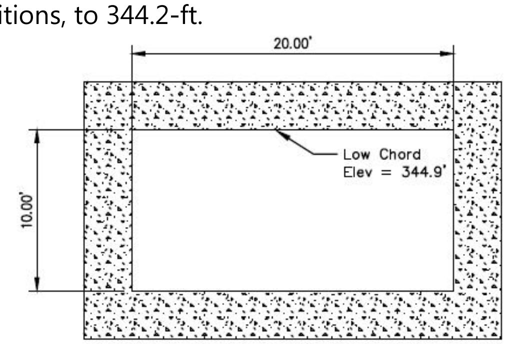


CULVERT ALTERNATIVE #2: REUSE EXISTING SLAB, NEW CULVERT

SCALE: 1"=10' SOURCE: VHB DATE: NOV 15 2016

Culvert Alternative 3 – 20-ft x 10-ft Box Culvert:

Culvert alternative 3 is a new precast concrete box culvert measuring 20-ft wide by 10-ft tall. VHB assumed the culvert to be slightly embedded but without any channel side slopes within the culvert. Culvert three, presumably the cheapest option, has the smallest hydraulic opening with 200-sqft with a low chord of 344.9-ft. This option has 2.1-ft of freeboard and meets the VTrans hydraulic requirement to pass the Q25 flow with 1.0-ft of freeboard. This option does not spans the BFW of 40-ft. In the Q_{100} storm event, the water surface elevations increase around the culvert by 0.5-ft, as compared to existing conditions, to 344.2-ft.



CULVERT ALTERNATIVE #3: BOX CULVERT

SCALE: 1"=10' SOURCE: VHB DATE: NOV 15 2016

PROPOSED OPTIONS SUMMARY

Table 4: The following table summarizes the scenarios investigated and the design event (Q25) model results with a free discharge situation.

Scenario	Natural	Existing	Alt 1	Alt 2	Alt 3
Spans	NA	1	1	1	1
Max Span Length (feet)	NA	28	55	31.4	20
Out-to-Out Width (feet)	NA	78	78	78	78
Stone Fill	NA	NA	Type II	Type II	Type II
Low Chord (feet)	NA	343.0	346.7	347.2	344.9
Hydraulic Opening (SF)	NA	144.8	637.9	367.4	200.0
Velocity (feet/sec)					
160' DS of DS Culvert Face	2.1	3.55	3.5	3.5	3.5
36' DS of DS Culvert Face	0.9	1.9	2.0	1.9	1.9
DS Culvert Face	0.7	2.4	4.0	2.4	2.4
US Culvert Face	0.9	2.7	5.4	2.8	2.5
45' US of US Culvert Face	1.1	4.4	5.1	4.5	3.9
81' US of US Culvert Face	1.5	6.1	7.2	6.3	5.3
WSE (feet)					
160' DS of DS Culvert Face	341.7	341.7	341.4	341.7	341.7
36' DS of DS Culvert Face	341.8	341.9	341.9	341.9	341.9
DS Culvert Face	341.8	341.9	341.0	341.9	341.9
US Culvert Face	341.8	342.5	341.5	342.4	343.0
45' US of US Culvert Face	341.8	342.4	341.8	342.3	342.9
81' US of US Culvert Face	341.8	342.2	341.5	342.1	342.8
Freeboard (feet)					
160' DS of DS Culvert Face	NA	1.3	5.3	5.5	3.2
36' DS of DS Culvert Face	NA	1.1	4.8	5.3	3.0
DS Culvert Face	NA	1.1	5.7	5.3	3.0
US Culvert Face	NA	0.5	5.2	4.8	1.9
45' US of US Culvert Face	NA	0.6	5.0	4.9	2.0
81' US of US Culvert Face	NA	0.8	5.2	5.1	2.1

Freeboard is in reference to WSE to the height of the low chord of the bridge

All Elevations based on NAVD88

SUMMARY: The model demonstrated that water surface elevations through the Leicester River culvert crossing are primarily driven by Otter Creek even at smaller bank full storm evetns. Assuming a free discharge condition, the existing culvert would only provide 0.83-ft of freeboard during the Q25 event and does not meet the hydraulic standard. The existing culvert does not span the BFW of 40-ft.

Alternative 1 would increase the existing span to 55-ft and is predicted to meet the hydraulic standard by providing 5.2-ft of freeboard during the Q25 event to the low chord elevation of 346.7-ft. The alternative would span the BFW of 40-ft and would not result in an increase in the Q100 WSE as compared to existing conditions.

Alternative 2 would increase the existing span to 31.4-ft and is predicted to meet the hydraulic standard by providing 5.1-ft of freeboard during the Q25 event to the low chord elevation of 347.2-ft. The alternative does not span the BFW of 40-ft. This alternative would not result in an increase in the Q100 WSE as compared to existing conditions.

Alternative 3 would replace the existing arch culvert with a 20-ft (w) by 10-ft (10) box culvert. This alternative is predicted to meet the hydraulic standard by providing 2.1-ft of freeboard during the Q25 event to the low chord elevation of 344.9-ft. The alternative does not span the BFW of 40-ft. This alternative would result in an increase in the Q100 WSE by 0.5-ft as compared to existing conditions.

Summary of SMS Model Runs created for Preliminary Design:

Flow Conditions used: free discharge, 80% (1.25 Yr), 43% (2.33 Yr), 4% (25 Yr), 10% (10 Yr) 2% (50 Yr), 1% (100 Yr)

- Existing Conditions
- Natural Conditions
- Culvert Alternative 1: New culvert
- Culvert Alternative 2: Re-use existing concrete slab & New culvert
- Culvert Alternative 3: New Concrete Box Culvert

Proposal Constraints:

No known constraints

Scour:

Scour will be calculated with final hydraulics.

Stone Fill:

Based on velocities and channel conditions, it is anticipated that a minimum Type II Stone Fill will be required to armor the abutment and channel banks based on the modeling velocities.

Temporary Bridge:

VHB did not evaluate the necessity for a temporary bridge during construction.

CADD Data Files:

s12j636nu1.dgn

From:	Lizewski, Ryan
To:	Sweeny, Gary
Cc:	Wark, Nick; Russell, Leslie
Subject:	RE: Preliminary Hydraulics Report - Leicester (37)
Date:	Tuesday, November 22, 2016 7:45:10 AM

Good Morning Gary,

You are correct, based on our analysis flooding in this area is driven by otter creek and structure sizing for the crossing would be driven by tailwater from Otter Creek for all storm event analyzed. Below is the water surface elevations within otter creek for the joint probability model runs:

Otter Storm	Leicester storm	Otter Creek WSEs
2.33	2.33	349.4
10	10	354.9
10	25	355.4
20	50	357.9
50	100	361.0
100	200	363.6

- Based on the survey the overtopping elevation for the roadway at the culvert is approx. 349.3-ft. There is another low spot in the road near the 36-inch culvert. The elevation of the roadway at this location is 347.7-ft based on LiDAR. Our analysis predicts the roadway would just begin to overtop near the culvert around the Q2.33 (42.9% AEP) based on the joint probably model runs. The roadway near the 36-inch culvert is predicted to overtop in events smaller than the Q2.33. Is there any anecdotal evidence to support the frequency of flooding predicted? Based on our site visit and analysis, frequent flooding of this area seems probable.

- Based on the free discharge scenarios, the roadway would overtop near the 36-inch culvert during the Q25 (4% AEP). However, it would not overtop the road at the subject bridge location for any of the storms analyzed (assuming free discharge).

- We evaluated the 28-ft box culvert for the Q25 (4% AEP) and Q100 (1% AEP) events. The upstream WSE during the Q25 (4% AEP) would be 342.2-ft which provides 2.1-ft of freeboard to the low chord (344.9-ft). During the Q100 (1% AEP), the WSE upstream from the bridge would be 343.7-ft which is 0.1-ft lower than the existing Q100 WSE assuming free discharge.

We will incorporate these findings and Otter Creek results into our memo. Please let me know if I can expand on any of these statements or if you would like us to evaluate another scenario.

Thanks,
-Ryan

Ryan Lizewski
Water Resources Engineer

P 617.607.2684
www.vhb.com

From: Sweeny, Gary [mailto:Gary.Sweeny@vermont.gov]
Sent: Friday, November 18, 2016 2:35 PM
To: Lizewski, Ryan <RLizewski@VHB.com>
Cc: Wark, Nick <Nick.Wark@vermont.gov>; Russell, Leslie <Leslie.Russell@vermont.gov>
Subject: Preliminary Hydraulics Report - Leicester (37)

Ryan:

Thanks for the phone conversation this morning with Nick, Leslie, Jenn, and me. Below are points made and questions:

- Although the Preliminary Hydraulics Report mentions that the tailwater from Otter Creek drives the water surface elevations, it focuses mostly on the free flow condition. You mentioned on the phone that the Otter Creek governs at any flow above Bank Full Width (BFW), which is at $Q_{1.25}$.. My understanding is that for the free flow condition to exist, the flow in the Otter Creek would need to be that or less, and the Leicester River would have to be in a Q_{25} flood condition. The probability of both conditions occurring simultaneously is even less, although the specific probability is unknown.
- Can you tell us the WSE for the Otter Creek at the 10 year and 25 year events?
- Can you tell us the frequency at which the roadway overtops? Our survey gives us a roadway crown elevation of approximately 349.
- The small box that you modeled showed a WSE increase of 0.5' upstream for the 100 year event. Alternative 2 showed a slight decrease. Could you run an alternative with about a 28' box – trying to hit a near zero increase in the Q_{100}.

Thanks for your help.

Gary

Gary Sweeny, PE
Structures Section
Vermont Agency of Transportation
1 National Life Dr.
Montpelier, Vermont 05633-5001
802 828-0049

Appendix E: Geotechnical Data Report

To: Nick Wark, P.E. Structures Project Manager

END CEE

From: Eric Denardo, Geotechnical Engineer via Callie Ewald, P.E., Geotechnical Engineering Manager

Date: March 14, 2017

Subject: Leicester BO 1445(37) – Subsurface Investigation

1.0 INTRODUCTION

We have completed our geotechnical and geological subsurface investigation for the culvert located on Leicester Town Highway 12 (Old Jerusalem Road) located approximately 0.74 miles north of the intersection of Old Jerusalem Road and Leicester-Whiting Road in Leicester, Vermont. The borings were completed to determine the soil strata and depth to bedrock to aid in design for a replacement structure. Contained herein are the results of our field sampling and testing, laboratory analyses of soil and rock samples, as well as boring logs.

2.0 FIELD INVESTIGATION

The field investigation was conducted between February 2, and February 14, 2017. Two standard penetration borings were drilled to determine the existing subsurface strata. A summary of the location of each boring and corresponding ground surface elevation can be found in Table 1 as well as in the attached Boring Location Plan. The values for the Northings and Eastings are based on the Vermont State Plane Grid Coordinate System NAD 83, and were located by a handheld GPS. Elevations for the borings were then taken off a VTrans survey file. The locations and elevations of the borings should be considered accurate only to the degree implied by the method used to determine them.

Table 1: Boring Locations and Elevations

Boring Number	Station	Offset(ft)	Northing (ft)	Easting (ft)	Ground Surface Elevation (ft)	Top of Bedrock Elevation (ft)
B – 101	11+71.31	-19.70	498548.53	1469562.96	347.7	289.0
B – 104	12+34.16	14.70	498619.60	1469558.18	348.5	284.7

The borings were performed in general accordance with AASHTO T206, *Standard Method of Test for Penetration Test and Split-Barrel Sampling of Soils.* During boring operations, for boring B-101, split spoon samples and standard penetration tests (SPT) were taken continuously until 28 feet and then at 5 foot intervals to bedrock. When bedrock was encountered, NX rock cores were taken 10 feet into bedrock to collect five foot core sample runs to confirm the presence of bedrock. For B-102, split spoon samples and SPTs were taken continuously to 32 feet, then at 5 foot intervals to bedrock. When bedrock was encountered, two five foot core runs were completed to confirm the presence of bedrock. In both borings, when cohesive soils were encountered during drilling operations, undisturbed sampling was performed in accordance with AASHTO T207, *Thin Walled Tube Sampling of Soils.*

Soil samples were visually identified in the field and SPT blow counts were recorded on the boring logs when applicable. Soil and rock samples were preserved and returned to the Construction and Materials Bureau Central Laboratory for testing and further evaluation. Upon completion of the laboratory testing, the boring logs were revised to reflect the results of the laboratory classification analysis.

3.0 FIELD AND LABORATORY TESTING

The standard penetration resistance of the in-situ soil is determined by the number of blows required to drive a 2 inch OD split barrel sampler into the soil with a 140 pound hammer dropped from a height of 30 inches, in accordance with procedures specified in AASHTO T206. During the standard penetration test (SPT), the sampler is driven for a total length of 2 feet, while counting the blows for each 6 inch increment. The SPT N-value, which is defined as the sum of the number of blows required to drive the sampler through the second and third increments, is commonly used with established correlations to estimate a number of soil parameters, particularly the shear strength and density of cohesionless soils. The N-values provided on the boring logs are raw values and have not been corrected for energy, borehole diameter, rod length, or overburden pressure. The VT Agency of Transportation has determined a hammer correction value, C_E, to account for the efficiency of the SPT hammer on the drill rig. For both of the borings, a CME 45C Skid Rig was used, with a hammer energy correction factor of 1.42. This value, included on the boring logs, should be used in calculations to determine soil parameters. Laboratory tests were conducted on all samples to evaluate grain size, moisture content, percent finer than No. 200 sieve, and liquid and plastic limits when applicable. Results from this testing can be found on the attached boring logs.

Undisturbed sampling was performed in the field and there are currently four 30-inch Shelby tubes of cohesive material ready for laboratory strength testing. Because the type of structure is not yet known, it’s difficult at this point to determine what tests to perform on the material. The tubes will be stored until such a time when a substructure type is chosen and testing can be completed to aid in the design of the structure foundation.

A detailed description of the rock cores is presented on the boring logs including run length, drill times, recovery, and Rock Quality Designation (RQD). Recovery is defined as the length of core obtained expressed as a percentage of the total length cored. In accordance with ASTM D6032, RQD is the total length of core pieces, 4 inches or greater in length, expressed as a percentage of the total length cored. RQD provides an indication of the integrity of the rock mass and relative extent of seams, jointing and bending planes. The Rock Mass Rating (RMR) is also included on the logs. RMR is AASHTO’s (LRFD Bridge Design Specification) recommended method of classifying rock, and is based on five different parameters that all have relative ratings which combine to form the RMR. These parameters include rock strength, RQD, joint spacing, joint condition, and groundwater (AASHTO Section 10.4.6.4).

4.0 SOIL PROFILE

Review of laboratory data and boring logs revealed the following information pertaining to the soil strata. It should be noted that groundwater elevations are subject to change given the fact that boreholes were generally left open for a short period of time. Because groundwater elevations can fluctuate seasonally and are affected by temperature and precipitation, groundwater may be encountered during construction when not previously noted in the logs.

B-101 The ground surface elevation at B-101 was approximately 347.7 feet. Groundwater was encountered before drilling operations on February 6, 2017 at a depth of 2 feet resulting in an approximate groundwater elevation of 345.7 feet.

Table 4.1: B-101 Soil Strata

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 12 feet	Loose Gravel
12 – 22 feet	Loose Sandy Silt
22 – 53 feet	Very Soft Clay
53 – 58.7 feet	Very Loose Sandy Silt
>58.7 feet	Bedrock

B-104 The ground surface elevation at B-104 was approximately 348.5 feet. Groundwater was encountered before drilling operations on February 14, 2017 at a depth of 5.3 feet resulting in an approximate groundwater elevation of 343.2 feet.

Table 4.2: B-104 Soil Strata

Depth (Below Ground Surface Elevation)	Soil Profile
0 – 3 feet	Medium Dense Sandy Gravel
3 – 20.5 feet	Very Loose Silt
20.5 – 63.8 feet	Very Soft Clay
>63.8 feet	Bedrock

5.0 RECOMMENDATIONS

In both borings, granular soils consisting of sand, silt, and gravel were encountered to depths of approximately 20 feet below the ground surface underlain with approximately 30 feet of clay to bedrock. Groundwater was encountered at depths of 2 feet and 5.3 feet in borings B-101 and B-104, respectively. Based on the groundwater and the soils encountered, dewatering in the granular material in the upper 20 feet within an excavation can likely be accomplished by open pumping from shallow sumps, temporary ditches, and trenches within and around the excavation limits. If the excavation needs to extend into the cohesive clay soil, dewatering may be more complicated. The dewatering of the cohesive clay soil can be accomplished but will most likely require advanced techniques such as wick drains, or a series of well points.

No large boulders or cobbles were noted by the drillers during boring operations. Based on this information, we believe steel sheet piles can be driven to bedrock in order to retain the roadway if phased construction is selected. As a result, it appears sheet piles can be driven by equipment commonly used by contractors in the region through the soils encountered. These recommendations are based on the information encountered at the boring locations and it should be noted that site conditions can vary across the project site.

Based on the very loose granular and soft cohesive materials encountered, spread footings for a box culvert and wingwalls may experience excessive settlement. Additionally, soils containing 4.8% to 44% of organic material were encountered in samples from 16 feet to 20 feet and 13 feet to 24 feet in borings B-101 and B-104, respectively. Organic material is highly compressible and results in subsidence at a slow rate that could lead to many foundation problems. Typically, organic material is recommended to be excavated, however, excavation at the depths encountered is likely not a practical or economically feasible solution.

The bedrock encountered during drilling operations was classified as hard, slightly weathered, poor to fair quality rock. Based on the subsurface conditions, if replacement of the structure is the chosen option for this project, we recommend a structure supported on piles as the best option with respect to geotechnical foundation design and mitigating risk with the problem soils at this site.

6.0 CONCLUSION

If you have any questions, or you would like to discuss this report, please contact us at (802) 828-2561. The boring logs are attached as available in the *M:Projects\12j636\MaterialsResearch* folder.

Enclosures: Boring Location Plan (1 page)
Boring Logs (4 pages)

cc: Gary Sweeny, PIIT Project Engineer
Electronic Read File/DJH
Project File/CEE
END

Z:\Highways\CMB\GeotechEngineering\Projects\Leicester BO 1445(37)\REPORTS\Leicester BO 1445(37) Geotechnical Data Report.docx

SOIL CLASSIFICATION

AASHTO

A1	Gravel and Sand
A3	Fine Sand
A2	Silty or Clayey Gravel and Sand
A4	Silty Soil - Low Compressibility
A5	Silty Soil - Highly Compressible
A6	Clayey Soil - Low Compressibility
A7	Clayey Soil - Highly Compressible

ROCK QUALITY DESIGNATION

R.Q.D. (%)	ROCK DESCRIPTION
<25	Very Poor
25 to 50	Poor
51 to 75	Fair
76 to 90	Good
>90	Excellent

SHEAR STRENGTH

UNDRAINED SHEAR STRENGTH IN P.S.F.	CONSISTENCY
<250	Very Soft
250-500	Soft
500-1000	Med. Stiff
1000-2000	Stiff
2000-4000	Very Stiff
>4000	Hard

CORRELATION GUIDE OF "N" TO DENSITY/CONSISTENCY

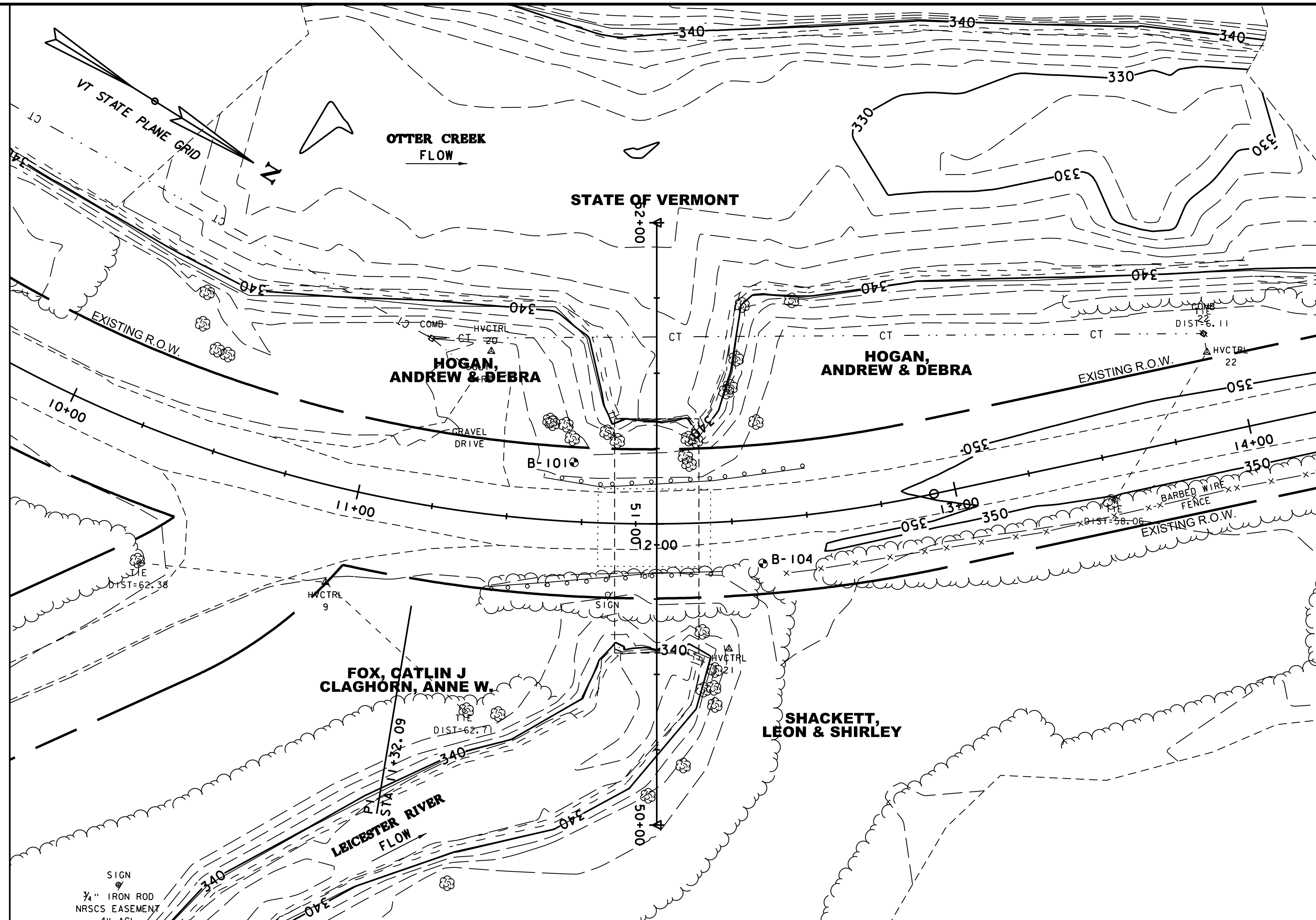
DENSITY (GRANULAR SOILS)		CONSISTENCY (COHESIVE SOILS)	
N	DESCRIPTIVE TERM	N	DESCRIPTIVE TERM
<5	Very Loose	<2	Very Soft
5-10	Loose	2-4	Soft
11-24	Med. Dense	5-8	Med. Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
		31-60	Hard
		>60	Very Hard

COMMONLY USED SYMBOLS

▼	Water Elevation
⊘	Standard Penetration Boring
⊕	Auger Boring
⊙	Rod Sounding
S	Sample
N	Standard Penetration Test Blow Count Per Foot For: 2" O.D. Sampler 1 3/8" I.D. Sampler Hammer Weight Of 140 Lbs. Hammer Fall Of 30"
VS	Field Vane Shear Test
US	Undisturbed Soil Sample
B	Blast
DC	Diamond Core
MD	Mud Drill
WA	Wash Ahead
HSA	Hollow Stem Auger
AX	Core Size 1 1/8"
BX	Core Size 1 5/8"
NX	Core Size 2 1/8"
M	Double Tube Core Barrel Used
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NP	Non Plastic
w	Moisture Content (Dry Wgt. Basis)
D	Dry
M	Moist
MTW	Moist To Wet
W	Wet
Sat	Saturated
Bo	Boulder
Gr	Gravel
Sa	Sand
Si	Silt
Cl	Clay
HP	Hardpan
Le	Ledge
NLTD	No Ledge To Depth
CNPF	Can Not Penetrate Further
TLOB	Top of Ledge Or Boulder
NR	No Recovery
Rec.	Recovery
%Rec.	Percent Recovery
RQD	Rock Quality Designation
CBR	California Bearing Ratio
<	Less Than
>	Greater Than
R	Refusal (N > 100)
VTSPG	NAD83 - See Note 7

COLOR

blk	Black	pnk	Pink
bl	Blue	pu	Purple
brn	Brown	rd	Red
dk	Dark	tn	Tan
gry	Gray	wh	White
gn	Green	yel	Yellow
lt	Light	mltc	Multicolored
or	Orange		



BORING LAYOUT

SCALE 1" = 20'-0"

20 0 20

BORING CHART

HOLE NO.	SURV. STATION	OFFSET	GROUND ELEV.	ELEV. TLOB
B-101	11+71.31	19.70LT	347.7	289.0
B-104	12+34.16	14.70RT	348.5	284.7

DEFINITIONS (AASHTO)

BEDROCK (LEDGE) - Rock in its native location of indefinite thickness.

BOULDER - A rock fragment with an average dimension > 12 inches.

COBBLE - Rock fragments with an average dimension between 3 and 12 inches.

GRAVEL - Rounded particles of rock < 3" and > 0.0787" (#10 sieve).

SAND - Particles of rock < 0.0787" (#10 sieve) and > 0.0029" (#200 sieve).

SILT - Soil < 0.0029" (#200 sieve), non or slightly plastic and exhibits no strength when air-dried.

CLAY - Fine grained soil, exhibits plasticity when moist and considerable strength when air-dried.

VARVED - Alternate layers of silt and clay.

HARDPAN - Extremely dense soil, cemented layer, not softened when wet.

MUCK - Soft organic soil (containing > 10% organic material.

MOISTURE CONTENT - Weight of water divided by dry weight of soil.

FLOWING SAND - Granular soil so saturated (loose) that it flows into drill casing during extraction of wash rod.

STRIKE - Angle from magnetic north to line of intersection of bed with a horizontal plane.

DIP - Inclination of bed with a horizontal plane.

GENERAL NOTES

1. The subsurface explorations shown herein were made between Feb 2, 2017 and Feb 14, 2017 by the Agency.
2. Soil and rock classifications, properties and descriptions are based on engineering interpretation from available subsurface information by the Agency and may not necessarily reflect actual variations in subsurface conditions that may be encountered between individual boring or sample locations.
3. Observed water levels and/or conditions indicated are as recorded at the time of exploration and may vary according to the prevailing rainfall, methods of exploration and other factors.
4. Engineering judgment was exercised in preparing the subsurface information presented herein. Analysis and interpretation of subsurface data was performed and interpreted for Agency design and estimating purposes. Presentation of the information in the Contract is intended to provide the Contractor access to the same data available to the Agency. The subsurface information is presented in good faith and is not intended as a substitute for personal investigation, independent interpretation, independent analysis or judgment by the Contractor.
5. Pictorial structure details shown on the boring plan layout or soils profile are for illustrative purposes only and may not accurately portray final contract details.
6. Terminology used on boring logs to describe the hardness, degree of weathering, and spacing of fractures, joints and other discontinuities in the bedrock is defined in the AASHTO Manual on Subsurface Investigations, 1988.
7. Northing and Easting coordinates are shown in Vermont State Plane Grid North American Datum 1983 in meters and survey feet.

PROJECT NAME:	LEICESTER
PROJECT NUMBER:	BO 1445(37)

FILE NAME: 15b094/s15b094boring.dgn	PLOT DATE: $$$$DATE$$$
PROJECT LEADER: J.FITCH	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
BORING INFORMATION SHEET	SHEET $$S*$ OF $T*$

VTrans Working to Get You There, Vermont Agency of Transportation	STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG **Leicester** **BO1445(37)** **TH 12**	Boring No.: **B-101** Page No.: 1 of 2 Pin No.: 12j636 Checked By: END

Boring Crew: Judkins, Garrow, Olden
Date Started: 2/02/17 Date Finished: 2/06/17
VTSPG NAD83: N 498548.53 ft E 1469562.96 ft
Station: 11+71.31 Offset: -19.70
Ground Elevation: 347.7 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 45C SKID	C_E = 1.42

Groundwater Observations

Date	Depth (ft)	Notes
02/06/17	2.0	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %	LL %	PI %
		A-1-b, Gr, brn, Moist, Rec. = 1.1 ft				9-6-6-5 (11)	18.1	65.4	17.9	16.7		
		Field Note:, NXDC, Cleaned out casing										
		Visual Description:, Broken Rock, Rec. = 0.1 ft, Field Note: Rock stuck in end of sampler				3-R@2.5" (R)						
5		A-1-a, Gr, brn, Moist, Rec. = 0.5 ft, Lab Note: Broken rock was within sample				17-10-6-5 (16)	6.4	81.9	6.0	12.1		
		A-1-a, Gr, brn, Moist, Rec. = 0.6 ft, Lab Note: Broken rock was within sample Field Note:, NXDC, Cleaned out casing				6-6-5-8 (11)	8.1	80.7	8.8	10.5		
		Field Note:, No Recovery				8-4-3-3 (7)						
10		Field Note:, NXDC, Cleaned out casing										
		Field Note:, No Recovery				5-3-1-2 (4)						
		Field Note:, NXDC, Cleaned out casing										
		Field Note:, No Recovery Field Note:, NXDC, Cleaned out casing				3-6-5-3 (11)						
15		A-4, SaSi, gry-brn, Moist, Rec. = 0.7 ft				6-5-2-1 (7)	44.1	12.9	32.9	54.2		
		Field Note:, NXDC, Cleaned out casing										
		A-4, SaSi with trace organics, gry-brn, Moist, Rec. = 1.9 ft, Lab Note: Sample contained a trace (7%) organics (AASHTO T-267). Decomposing wood was noticeable in sample				4-4-4-5 (8)	66.8	2.9	38.6	58.5		
						1-1-2-4 (3)	179.9	16.1	45.0	38.9		
20		A-8, Organic Si, brn, Moist, Rec. = 1.6 ft, Lab Note: Sample contained 26.9% organics (AASHTO T-267) Field Note:, NXDC, Cleaned out casing										
		Field Note:, No Recovery				3-1-1-1 (2)						
		A-7-6, Cl, gry, Moist, Rec. = 1.7 ft				1-1-2-2 (3)	36.6	0.6	6.8	92.6	48	24
25		A-7-6, Cl										
		A-7-6, Cl, gry, Moist, Rec. = 2.1 ft				(WH)	70.2		0.3	99.7	69	40
		Field Note:, NXDC, Cleaned out casing										
30		A-7-6, Cl										
		A-7-6, Cl, gry, Moist, Rec. = 2.0 ft				(WH)	64.1	0.1	0.3	99.6	50	27
		Field Note:, NXDC, Cleaned out casing										
35		A-7-6, Cl, gry, Wet, Rec. = 2.0 ft, Lab Note: Sample had similar Atterberg limits to 32-34 foot sample				(WR)	75.7		0.1	99.9		

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

BORING LOG

Leicester
BO1445(37)
TH 12

Boring Crew: Judkins, Garrow, Olden
Date Started: 2/02/17 Date Finished: 2/06/17
VTSPG NAD83: N 498548.53 ft E 1469562.96 ft
Station: 11+71.31 Offset: -19.70
Ground Elevation: 347.7 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.

Hammer/Rod Type: Auto/AWJ
Rig: CME 45C SKID C_E = 1.42

Groundwater Observations

Date	Depth (ft)	Notes
02/06/17	2.0	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %	LL %	PI %
40		A-7-6, Cl, gry, Wet, Rec. = 2.0 ft, Lab Note: Sample had similar Atterberg limits to 32-34 foot sample				(WR)	63.5		0.2	99.8		
45		A-7-6, Cl, gry, Wet, Rec. = 2.0 ft, Lab Note: Sample had similar Atterberg limits to 50-52 foot sample				WR-WH	74.1		0.1	99.9		
50		A-7-6, Cl, gry, Wet, Rec. = 2.0 ft				(WR)	49.7	3.3	0.8	95.9	43	22
55		A-4, SaSi, gry, Wet, Rec. = 1.1 ft				1-1-WH (1)	61.3	2.7	39.9	57.4		
60		58.7 ft - 63.7 ft, Light gray, DOLOMITIC MARBLE, with red and beige dolomite beds. Brown staining and secondary calcite precipitation along joints. Hard, Very slightly weathered, Fair rock, NX, RMR=52	1 (60)	76 (32)	7, 5, 4, 4, 5		Top of Bedrock @ 58.7 ft					
65		63.7 ft - 68.7 ft, Light gray, DOLOMITIC MARBLE, with red and beige dolomite beds. Sub-vertical joint from 64.15 feet to 64.7 feet. Brown and yellow staining with secondary calcite precipitation along joints. Hard, Slightly weathered, Fair rock, NX, RMR=49	2 (60)	84 (46)	5, 5, 7, 5, 3							
70		Hole stopped @ 68.7 ft										

Remarks:
Hole collapsed at 1.2 feet.

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	BORING LOG	Boring No.:	**B-104**
VTrans Working to Get You There — Vermont Agency of Transportation	**Leicester**	Page No.:	1 of 2
	BO1445(37)	Pin No.:	12j636
	TH 12	Checked By:	END

				Casing	Sampler
Boring Crew:	Emerson, Garrow, Olden		Type:	WB	SS
Date Started:	2/07/17	Date Finished: 2/14/17	I.D.:	4 in	1.5 in
VTSPG NAD83:	N 498619.60 ft E 1469558.18 ft		Hammer Wt:	N.A.	140 lb.
Station:	12+34.16	Offset: 14.70	Hammer Fall:	N.A.	30 in.
Ground Elevation:	348.5 ft		Hammer/Rod Type:	Auto/AWJ	
			Rig:	CME 45C SKID	C_E = 1.42

Groundwater Observations

Date	Depth (ft)	Notes
02/08/17	8.2	W.T. before drilling
02/14/17	5.3	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %	LL %	PI %
		A-1-b, SaGr, brn, Dry, Rec. = 1.4 ft				9-10-7-19 (17)	15.1	51.9	29.9	18.2		
		A-1-b, SaGr, gry, Dry, Rec. = 0.6 ft, Lab Note: Broken rock was within sample				15-13-5-5 (18)	3.9	61.6	22.0	16.4		
		Field Note:, NXDC, Cleaned out casing					21.8	13.2	32.0	54.8		
5		A-4, SaSi, brn, Dry, Rec. = 0.9 ft, Lab Note: Plant material was within sample				6-6-4-5 (10)	24.5	0.8	21.1	78.1		
		A-4, SaSi, brn, Moist, Rec. = 1.5 ft										
		A-4, Si, gry, Moist, Rec. = 0.9 ft				5-4-6-4 (10)	27.9	0.9	17.9	81.2		
		Field Note:, No Recovery				4-3-4-4 (7)						
10		Field Note:, No Recovery				1-2-1-1 (3)						
		A-4, SaSi, gry, Moist, Rec. = 0.9 ft, Lab Note: Sample contained trace (4.8%) organics (AASHTO T-267)				1-1-1-1 (2)	61.3	0.2	30.6	69.2		
							140.7	10.5	59.8	29.7		
15		A-8, Organic Si, blk, Moist, Rec. = 0.7 ft, Lab Note: Sample contained little (18.3%) organics (AASHTO T-267). Decomposing wood was noticeable in sample				WH-1-1 (1)	45.4	0.1	19.1	80.8		
		A-4, Si, gry, Moist, Rec. = 1.4 ft, Lab Note: A very small amount of clay and organic material was within sample. Sample tested non-plastic				WH-2-2 (2)	73.1	3.3	17.7	79.0		
20		A-4, Si, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample contained trace (7.2%) organics (AASHTO T-267). Decomposing wood and a thin layer of clay was noticeable within sample. Sample tested non-plastic				1-1-2-3 (3)	247.3	41.7	42.4	15.9		
						WH-2-4 (2)	315.4	27.7	59.4	12.9		
		A-8, Organic Si, brn, Moist, Rec. = 1.7 ft, Lab Note: Sample contained (44.0%) organics. Decomposing wood was noticeable in sample.					45.2	1.3	22.5	76.2		
						WH-2-2-4 (4)	49.4	0.1	1.2	98.7	69	40
		A-8, Organic Si, brn, Wet, Rec. = 0.5 ft, Lab Note: Sample contained (37.5%) organics. Decomposing wood was noticeable in sample.										
25		A-7-6, Cl, gry, Moist, Rec. = 1.2 ft, Lab Note: Sample contained a very small amount of organic material. Sample had similar Aterberg limits to 22-24 foot sample				(WH)	77.8	0.1	0.4	99.5	65	36
		A-7-6, Cl, gry, Moist, Rec. = 1.8 ft Field Note:, NXDC, Cleaned out casing										
		A-7-6, Cl, gry, Moist										
30		A-7-6, Cl, gry, Moist, Rec. = 2.0 ft										
		A-7-6, Cl, gry, Moist				(WH)	75.6		0.1	99.9		
		A-7-6, Cl, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample had similar Atterberg limits to 26-28 foot sample										
35		A-7-6, Cl, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample had similar Atterberg limits to 26-28 foot sample				(WR)	80.7		0.2	99.8		

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

VTrans Working to Get You There, Vermont Agency of Transportation STATE OF VERMONT AGENCY OF TRANSPORTATION CONSTRUCTION AND MATERIALS BUREAU CENTRAL LABORATORY	**BORING LOG** **Leicester** **BO1445(37)** **TH 12**	Boring No.: **B-104** Page No.: 2 of 2 Pin No.: 12j636 Checked By: END

Boring Crew: Emerson, Garrow, Olden
Date Started: 2/07/17 Date Finished: 2/14/17
VTSPG NAD83: N 498619.60 ft E 1469558.18 ft
Station: 12+34.16 Offset: 14.70
Ground Elevation: 348.5 ft

	Casing	Sampler
Type:	WB	SS
I.D.:	4 in	1.5 in
Hammer Wt:	N.A.	140 lb.
Hammer Fall:	N.A.	30 in.
Hammer/Rod Type:	Auto/AWJ	
Rig:	CME 45C SKID	C_E = 1.42

Groundwater Observations

Date	Depth (ft)	Notes
02/08/17	8.2	W.T. before drilling
02/14/17	5.3	W.T. before drilling

Depth (ft)	Strata (1)	CLASSIFICATION OF MATERIALS (Description)	Run (Dip deg.)	Core Rec. % (RQD %)	Drill Rate minutes/ft	Blows/6" (N Value)	Moisture Content %	Gravel %	Sand %	Fines %	LL %	PI %
40		A-7-6, Cl, gry, Moist, Rec. = 2.0 ft, Lab Note: Sample had similar Atterberg limits to 45-47 foot sample				(WR)	80.5		0.3	99.7		
45		A-7-6, Cl, gry, Moist, Rec. = 2.0 ft				(WH)	73.1	0.1	1.0	98.9	63	35
		Field Note:, NXDC, Cleaned out casing										
50		A-7-6, Cl, gry, Moist, Lab Note: Sample had similar Atterberg limits to 45-47 foot sample				(WR)	47.3	0.2	3.6	96.2		
55		Field Note:, No Recovery				(WH)						
60		Field Note:, No Recovery, Rec. = 1.0 ft				(WH)						
65		63.8 ft - 68.8 ft, Light gray, DOLOMITIC MARBLE, with red and beige dolomite beds. Sub-vertical joints from 63.8 feet to 64.45 feet and 65.4 feet to 65.9 feet. Orange and yellow staining with secondary calcite precipitation along joints. Hard, Slightly weathered, Poor rock, NX, RMR=39	1 (50-60)	100 (0)	4 6 6 5 4		Top of Bedrock @ 63.8 ft					
70		68.8 ft - 73.8 ft, Light gray, DOLOMITIC MARBLE, with red and beige dolomite beds. Yellow and brown staining along joints. Some secondary calcite precipitation along joints. Silt coated sub-vertical joint noted from 70.05 feet to 70.30 feet. Hard, Slightly weathered, Fair rock, NX, RMR=54	2 (20)	82 (46)	10 11 9 8 9							
75		Hole stopped @ 73.8 ft Remarks: Hole collapsed at 59.0 feet.										

Notes:
1. Stratification lines represent approximate boundary between material types. Transition may be gradual.
2. N Values have not been corrected for hammer energy. C_E is the hammer energy correction factor.
3. Water level readings have been made at times and under conditions stated. Fluctuations may occur due to other factors than those present at the time measurements were made.

Appendix F: Natural Resources ID

State of Vermont
Program Development Division
One National Life Drive
Montpelier, VT 05633-5001
www.aot.state.vt.us

[phone] 802-828-3979
[fax] 802-828-2334
[ttd] 800-253-0191

Agency of Transportation

Memorandum

To: Jeff Ramsey, VTrans Environmental Specialist

From: Glenn Gingras, VTrans Environmental Biologist

Date: 12/11/2015

Subject: Leicester BO 1445(37)
Natural Resource ID

I have completed my natural resource assessment of the project area referenced above. My review has consisted of reviewing available natural resource mapping, reviewing information in the project file and conducting a field visit to the project.

The project involves a culvert project on TH12 at the location of culvert # 4 in the town of Leicester. The culvert is located at the confluence of the Leicester River and the Otter Creek. The setting of the project is within the floodplain of the Otter Creek which is surrounded by mixed agricultural use and forested areas. Much of the area is highly likely to be flooded during high water events.

Wetlands/Watercourses:

I reviewed the immediate area for presence of wetlands. My site visit was not made during the growing season so boundaries were based on best professional judgement using wetland indicators that were present. Much of the area had been mowed and hard frosts had occurred so herbaceous vegetation was difficult to identify. Based on site conditions, wetlands were identified to occur in all quadrants besides the NW quadrant, which appears to be a disturbed area that has been filled and managed for some time.

Wetlands within this project area are really one wetland complex divided by the road and culvert. The wetland receives hydrology through frequent flooding of the Leicester River and Otter Creek as well as ground water. Hydric soils are present within the wetlands as several wetland hydric features where observed including redoximorphic features and depletions indicating that water moves within the upper layers of the soils. Wetland vegetation included trees such as Silver and Red Maple, Swamp White Oak and Elm. Herbaceous wetland understory included sensitive fern, ostrich fern, reed canary grass, golden rod, and horsetail. Wetland boundaries have been picked up by GPS Trimble XT unit and will be available for referencing as this project moves forward into alternative analysis.

As a side note, it appears that all the land to the east of the culvert has been put into the wetland reserve program of the natural resource conservation service. If impacts are proposed on that land coordination will likely need to occur with the manager of the lands.

The Leicester River and the Otter Creek are within the project area. The Otter Creek is a navigable water of the US and is a classified as warm-water fish habitat according to the VT Water Quality Standards. The Leicester River is classified as warm water fish habitat as well. Both of these waterways are regulated by the US Corps of Engineers and the Agency of Natural Resources.

A USCOE permit and VT Wetlands Permit will be required for this project if there are impacts to wetlands and waterways.

Rare, Threatened and Endangered (R/T/E) Species:

According to resource mapping from VT Fish and Wildlife there are R/T/E species located adjacent to this site. A freshwater mussel *Lasmigona compressa* is known to occur within this stretch of the Otter Creek which is immediately adjacent to this project. This species is a rare species that is on the list of species of greatest conservation needs (SGCN). Another species is the Blue spotted salamander *Ambystoma lateral* which is known to exist within this project area; this species is also on the SGCN list. A fresh water mussel survey may be required depending on the scope of the project and instream work.

The Northern Long Eared *Myotis septentrionalis* bat (NLEB) is listed on the federal list of threatened species (state endangered) statewide. The Indiana Bat *Myotis sodalis* (IBat) is federally listed endangered (state listed endangered). The Federal Highway Administration (FHWA) and Federal Railroad Administration (FRA) have implemented a Range-wide Programmatic Informal Consultation for Indiana Bat and Northern Long-eared Bat. The NLEB USFWS guidance indicates that all trees ≥ 3" in DBH, that exhibit: cracks, crevices, holes, and peeling bark are considered suitable habitat roost trees (dead or alive). Bridge structures are also considered as potential roost habitat. The IBat USFWS guidance indicates trees ≥ 5" DBH that exhibit: cracks, crevices, holes, and peeling bark are considered suitable habitat roost trees (dead or alive). Also landscape features such as hedgerows, riparian corridors, and forested woodlots are important for foraging, feeding and are used as travel corridors. There are several trees and landscape features nearby that fit this description. An acoustic survey can be completed between May 15-Aug 15 to determine absence/presence. This survey would be good for 5 years. Applicable avoidance and minimization measures (AMM) will need to be implemented if no survey is completed as we assume presence if there is suitable habitat present. Acceptable bridge AMM **if bats** are present include time of year restrictions on conducting work in the winter, bridge work being completed outside the pup season (JUN 1-JUL 31) at night, and various BMPs associated with protection of water quality and wetlands.

Agricultural Soils:
The soils in the project area are Winooski Very fine sandy loam, which are classified as prime agricultural soils.

Wildlife Habitat:
Aquatic organism passage will be required at this location. The current structure is not at bank full width. According to VT Fish and Wildlife mapping the area has low to moderate value wildlife habitat blocks. The area is mostly open agricultural lands with small blocks of forested and riparian habitat. Traffic volumes are low on this town highway so most large mammals should not be a concern. During alternative development the new structure should consider movement of smaller mammals, amphibians and reptiles as this is a riparian area. If the new structure is designed to accommodate bank full width this should not be a concern.

Cc
Jennifer Fitch, VTrans Project Manager
Natural Resource Environmental File

Appendix G: Archaeological Memo

Brennan Gauthier
VTrans Archaeologist
State of Vermont
Environmental Section
One National Life Drive
Montpelier, VT 05633-5001
Brennan.Gauthier@vermont.gov
802-828-3965

To: James Brady, VTrans Environmental Specialist

From: Brennan Gauthier, VTrans Archaeologist

Date: 10/20/2015

Subject: Leicester BO 1445(37) – Archaeological Resource ID

James,

I've completed my resource identification for Culvert 4 on TH-12 in the town of Leicester, Addison County, Vermont. Built in 1972, Culvert 4 is a buried reinforced concrete box culvert with a corrugated metal tube insert and is currently in poor condition. The Leicester River flows through Culvert 4 and converges with the Otter Creek only a dozen yards downstream and has been a major crossing in western Leicester since the early incorporation of the town in the late 18th century.

This area is considered highly sensitive for precontact Native American presence based on a series of positive environmental factors present within the general area. This sensitivity is confirmed with a tight cluster of known collector sites within the immediate project area. VT-AD-349, VT-AD-334 and VT-AD-264 are each found within 100 yards of the project APE. All three sites include diagnostic artifacts typically associated with the late Woodland period.

One area of potential historic archaeological interest was identified directly north of the project area based on background research and inspection of aerial imagery. According to records, the Elhanan Winchester Estey Property was once located in close proximity to the current culvert. In the 1970s, a team of archaeologists mapped out visible structural elements of the property as part of a larger survey. See **Figure 5** for further details.

Any work to be done outside of the current footprint will require Phase I testing. Please refer to the archaeology geodatabase for arch sensitivity lines. A map showing polygon location is attached to this resource ID. As always, feel free to contact me with questions or concerns that may arise.

Sincerely,

Brennan

Brennan Gauthier
VTrans Archaeologist
Vermont Agency of Transportation
Environmental Section
1 National Life Drive
Montpelier, VT 05633
tel. 802-828-3965
Brennan.Gauthier@vermont.gov

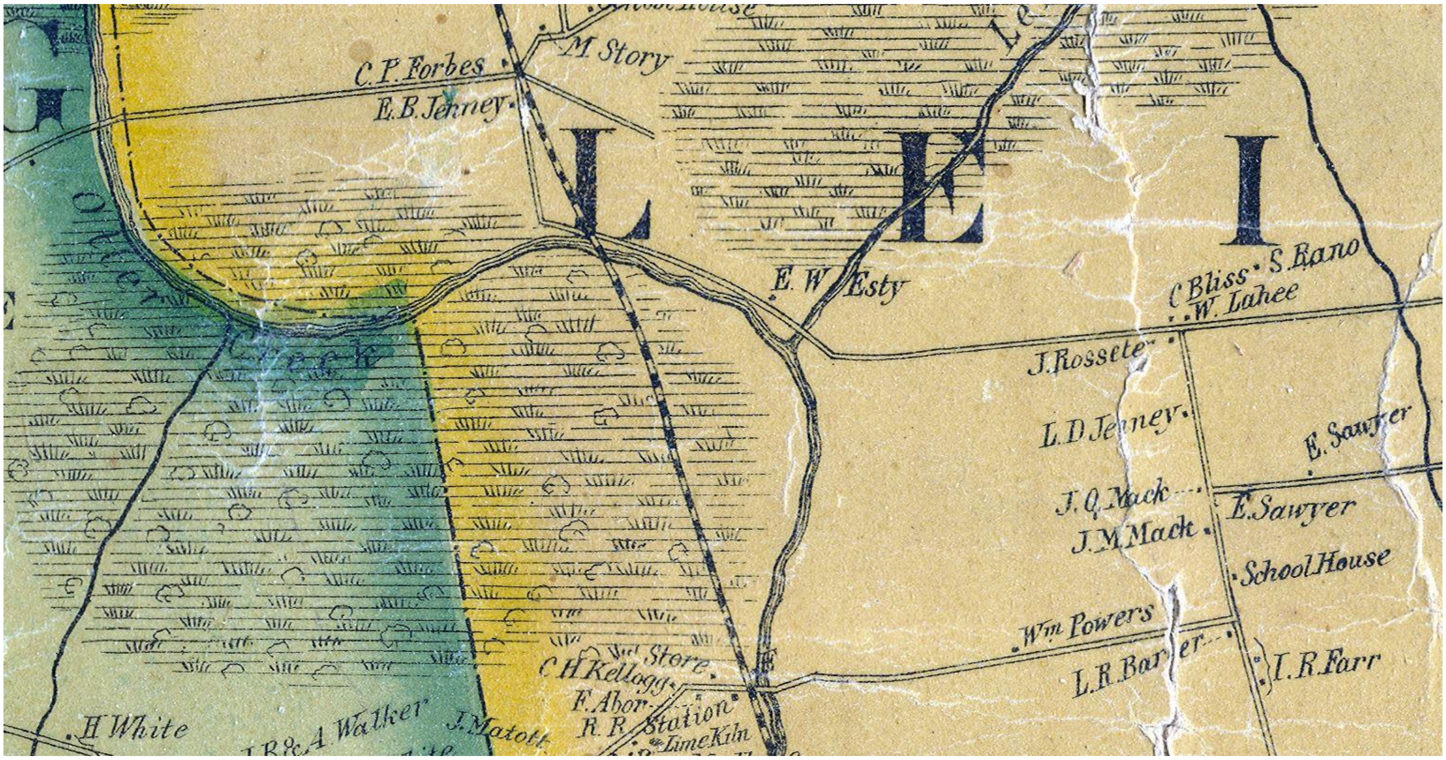


Figure 1: 1850s Beers map

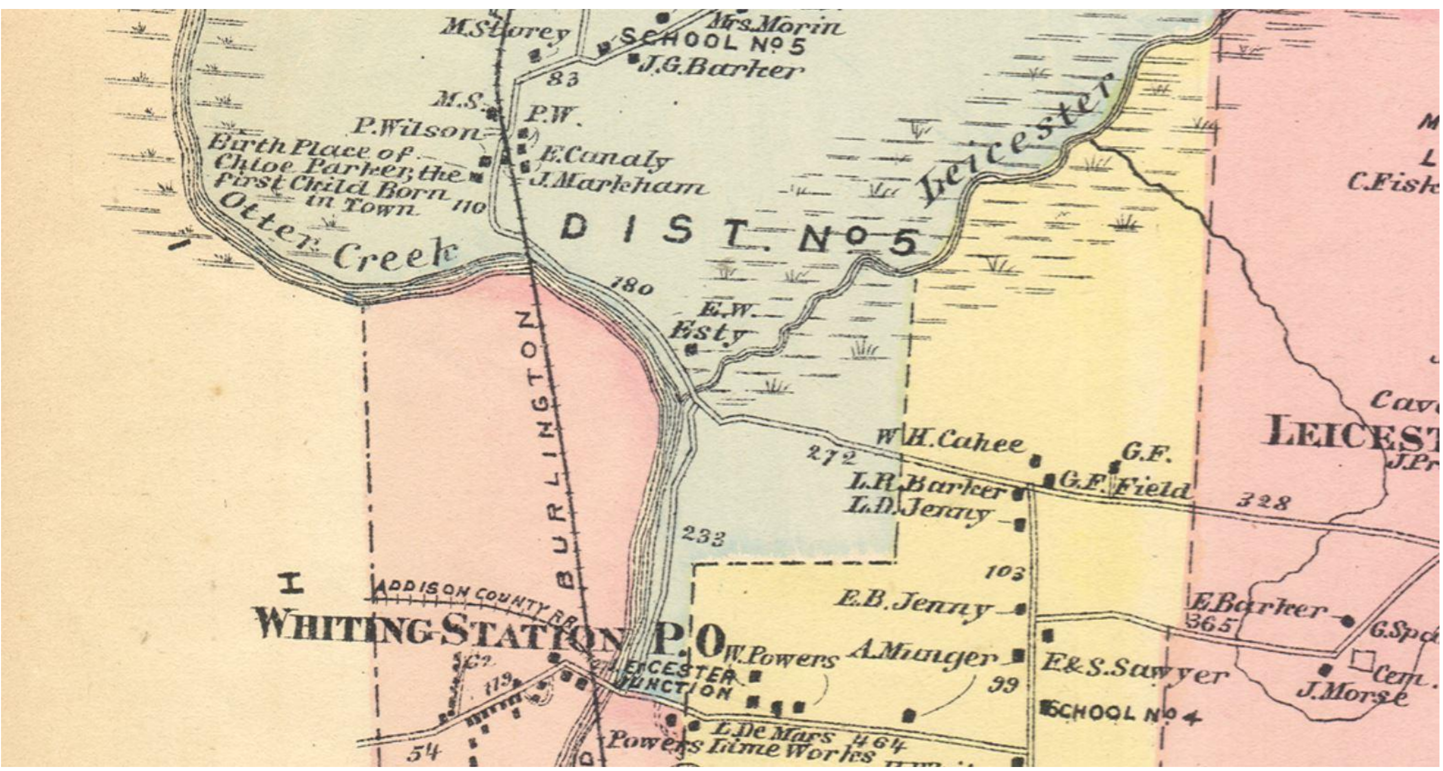


Figure 2: 1860s Walling Map

VERMONT

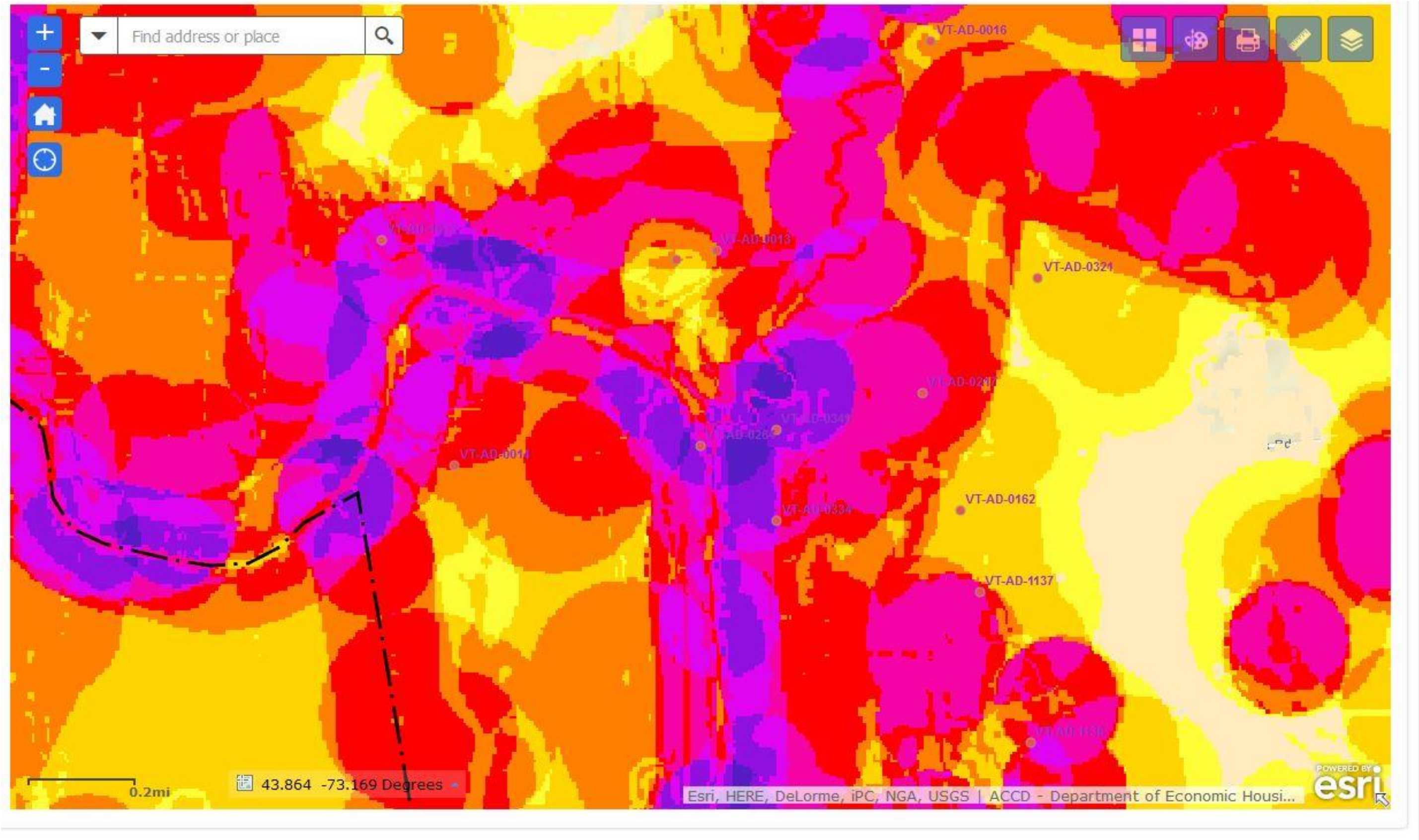


Figure 3: Environmental Predictive Model

Figure 4: 24k Topographic Map

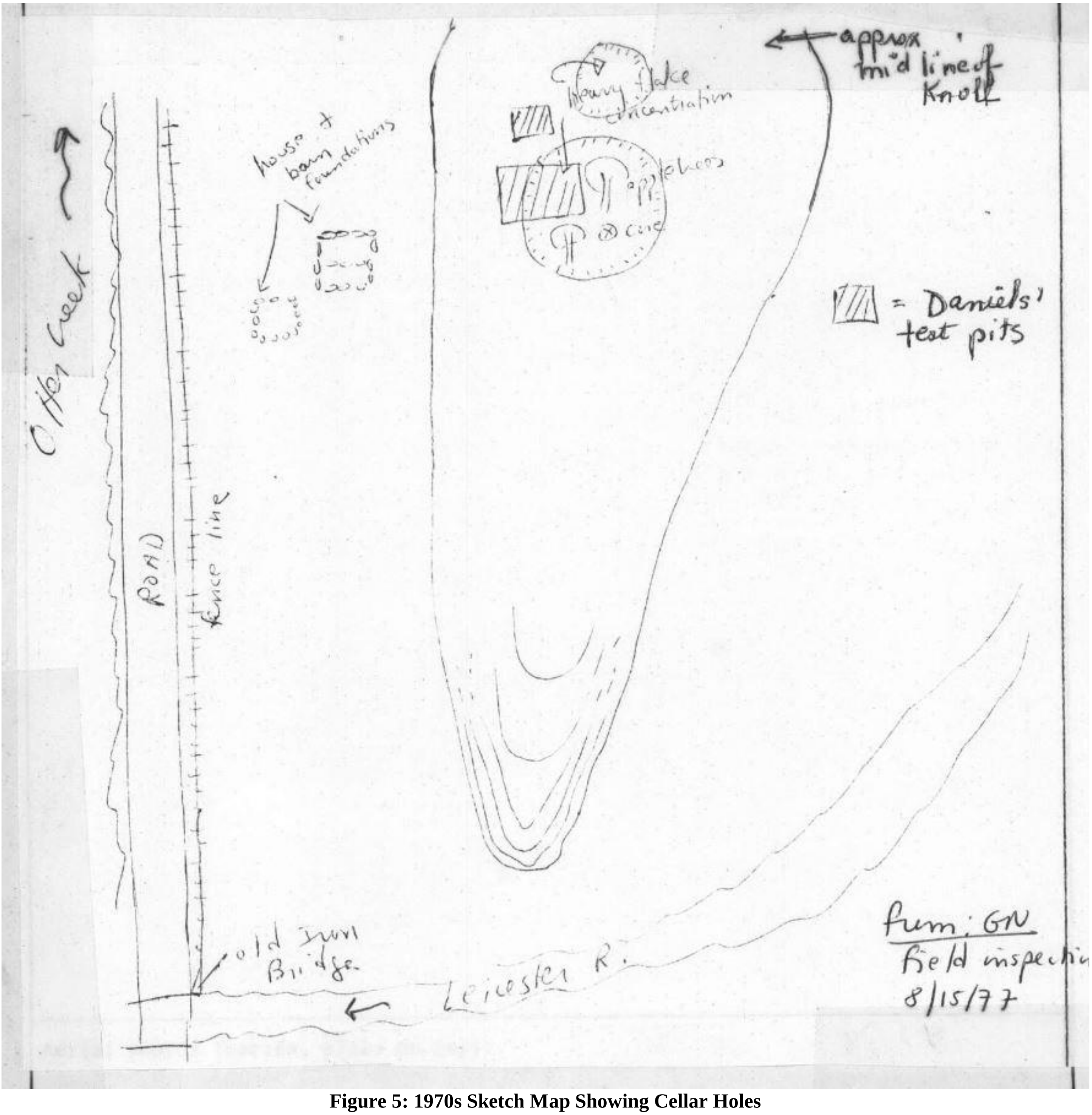
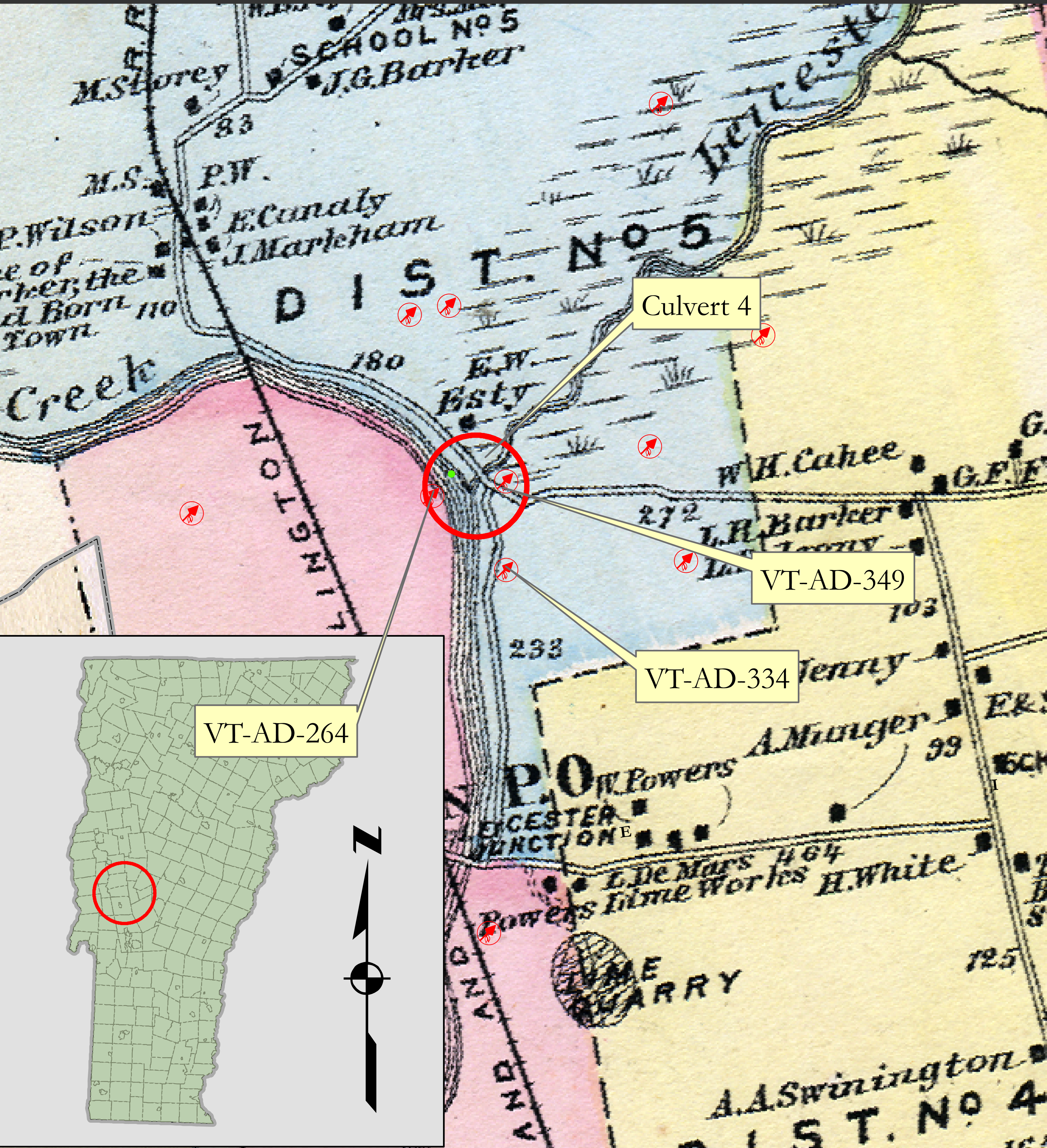


Figure 5: 1970s Sketch Map Showing Cellar Holes

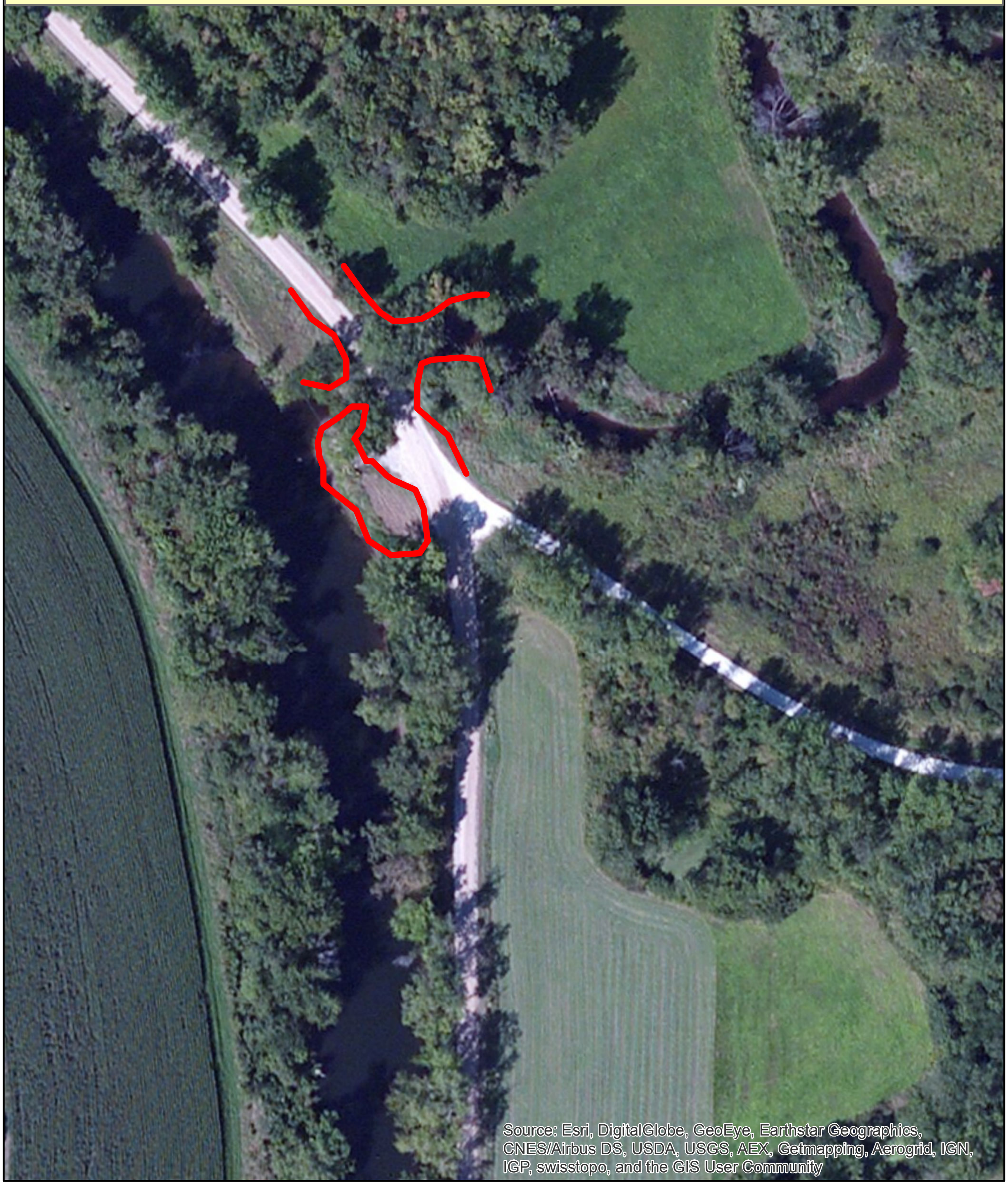
Figure 6: Cellar Hole Location

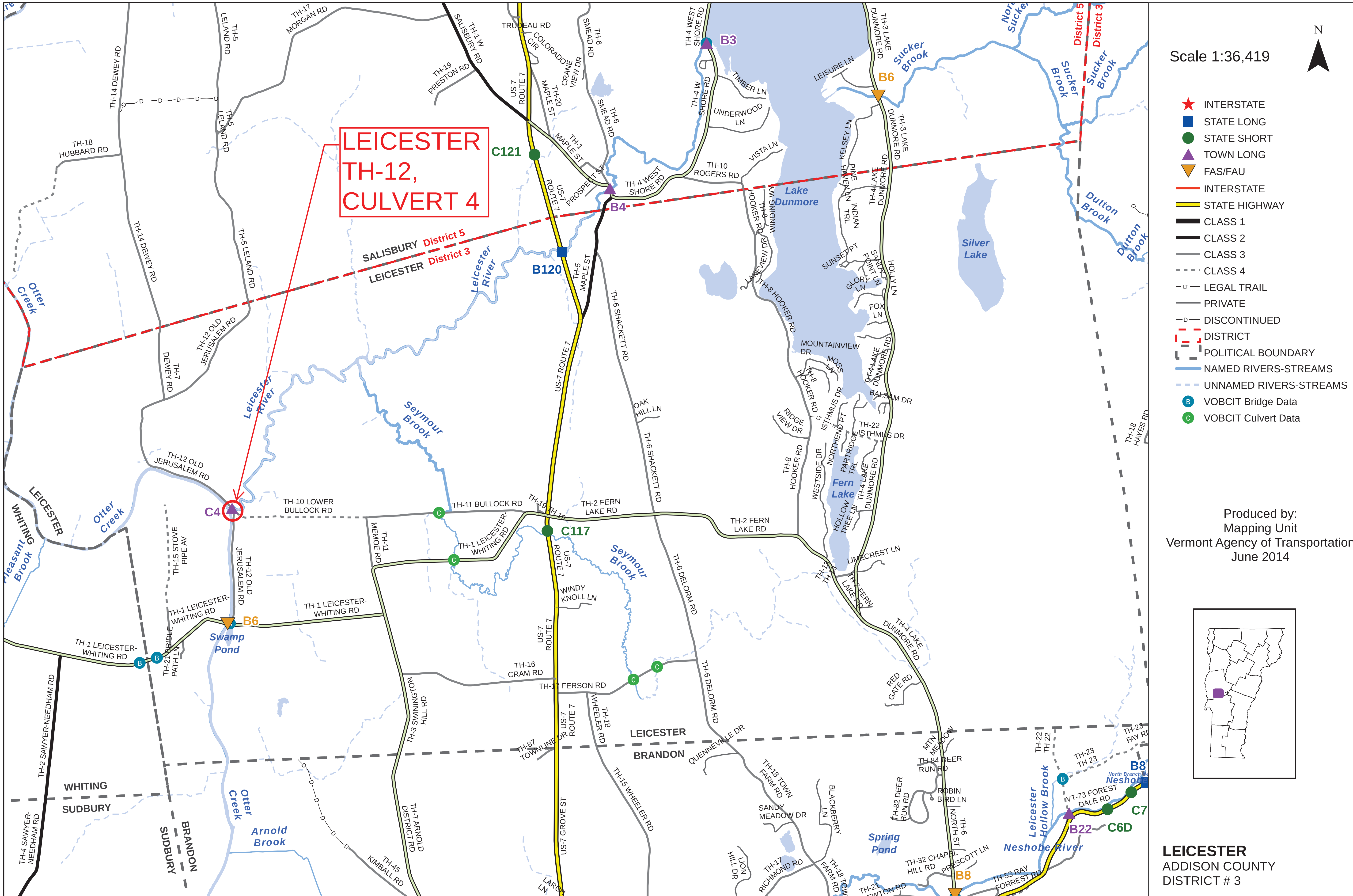
Leicester BO 1445(37)
Culvert 4 Replacement

1860s Beers Map



Leicester Culvert 4
Arch Sensitivity





LEICESTER
TH-12,
CULVERT 4
C4
C121
C117
B120
B3
B4
B6
B8
B22
C6D
C7
SALISBURY District 5
LEICESTER District 3
TH-12 OLD JERUSALEM RD
TH-10 LOWER BULLOCK RD
TH-11 BULLOCK RD
TH-2 FERN LAKE RD
TH-1 LEICESTER-WHITING RD
US-7 ROUTE 7
TH-6 SHACKETT RD
TH-6 DELORM RD
TH-5 LEELAND RD
TH-14 DEWEY RD
TH-4 LAKE DUNMORE RD
Leicester River
Seymour Brook
Otter Creek
Swamp Pond
Lake Dunmore
Silver Lake
Fern Lake
Sucker Brook
Dutton Brook
Arnold Brook
Spring Pond
Neshobe River
Leicester Hollow Brook
Pleasant Brook
LEICESTER
BRANDON
WHITING
SUDBURY
Scale 1:36,419
N
INTERSTATE
STATE LONG
STATE SHORT
TOWN LONG
FAS/FAU
INTERSTATE
STATE HIGHWAY
CLASS 1
CLASS 2
CLASS 3
CLASS 4
LEGAL TRAIL
PRIVATE
DISCONTINUED
DISTRICT
POLITICAL BOUNDARY
NAMED RIVERS-STREAMS
UNNAMED RIVERS-STREAMS
VOBCIT Bridge Data
VOBCIT Culvert Data
Produced by:
Mapping Unit
Vermont Agency of Transportation
June 2014
LEICESTER
ADDISON COUNTY
DISTRICT # 3

Appendix H: Historic Memo

Kyle Obenauer
Historic Preservation Specialist

Vermont Agency of Transportation

kyle.obenauer@vermont.gov
802.828.3962
www.vtrans.vermont.gov

Project Delivery Bureau - Environmental Section
One National Life Drive
Montpelier, VT 05633-5001

To: James Brady, VTrans Biologist/Environmental Specialist

Date: October 30, 2015

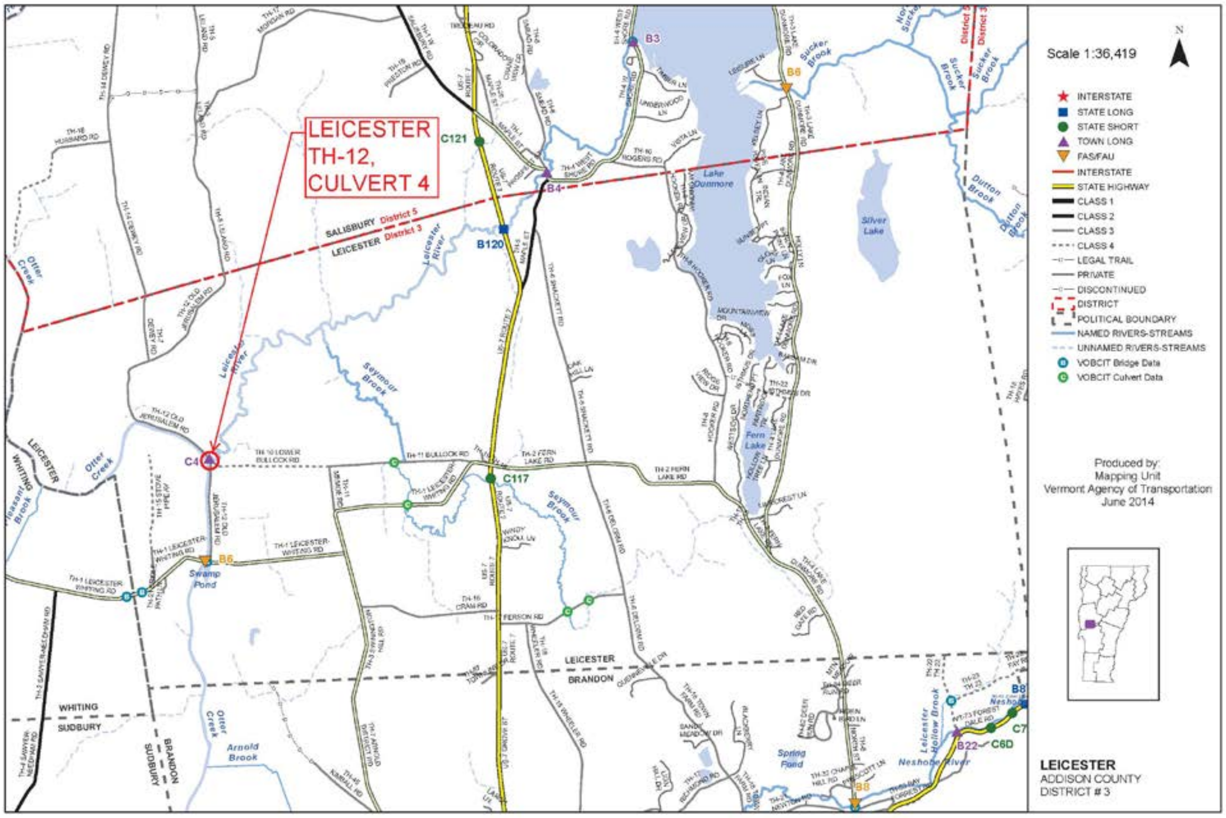
Subject: Resource Identification - BO 1445(37)

I have completed a resource identification (ID) for BO 1445(37), in Leicester, Vermont. This project includes the replacement of Culvert 4, a buried reinforced concrete box culvert with a large, deteriorated corrugated metal tube insert. Short galvanized steel supports with a single steel cable line Jerusalem Road on either side of Culvert 4 at its eastern and western approaches, while rusting barbed wire stapled to deteriorated, untreated wooden fence posts define the edge of a field, beginning at the western edge of Culvert 4.

None of these structures or landscape features are historically significant – the culvert is in poor condition and not architecturally or historically significant; the same is true for its steel and cable safety rails, as well as the remnants of a nearby wooden, barbed wire fence.

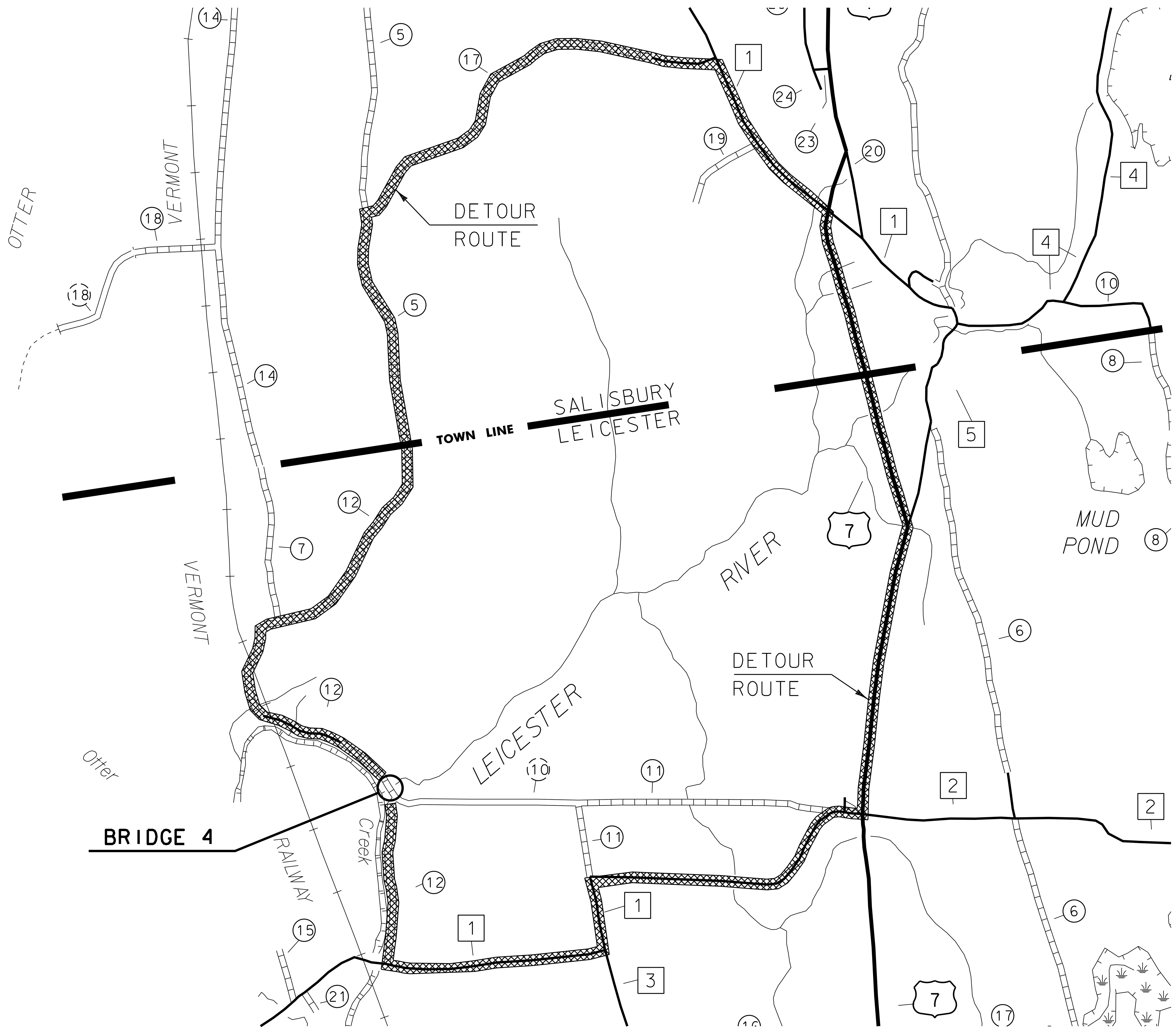
Please, let me know if you have any questions or if the scope of this project is changed.

Thanks,
Kyle



LEICESTER
TH-12,
CULVERT 4
Scale 1:36,419
N
INTERSTATE
STATE LONG
STATE SHORT
TOWN LONG
FAS/FAU
INTERSTATE
STATE HIGHWAY
CLASS 1
CLASS 2
CLASS 3
CLASS 4
LEGAL TRAIL
PRIVATE
DISCONTINUED
DISTRICT
POLITICAL BOUNDARY
NAMED RIVERS-STREAMS
UNNAMED RIVERS-STREAMS
VOBCIT Bridge Data
VOBCIT Culvert Data
Produced by:
Mapping Unit
Vermont Agency of Transportation
June 2014
LEICESTER
ADDISON COUNTY
DISTRICT # 3
SALISBURY District 5
LEICESTER District 3
LEICESTER
BRANDON
WHITING
SUDBURY
Lake Dunmore
Silver Lake
Fern Lake
Swamp Pond
Spring Pond
Otter Creek
Leicester River
Seymour Brook
Arnold Brook
Sucker Brook
Dutton Brook
Leicester Hollow Brook
Neshobe River
C4
B6
C121
B120
C117
B4
B3
B8
B22
C6D
C7

Appendix I: Detour Maps



PROJECT NAME: LEICESTER
PROJECT NUMBER: BO 1445(37)

FILE NAME: 12j636/12j636detour.dgn
PROJECT LEADER: N.WARK
DESIGNED BY: G.SWEENY
DETOUR ROUTE

PLOT DATE: 07-AUG-2017
DRAWN BY: D.D.BEARD
CHECKED BY: G.SWEENY
SHEET 1 OF 1

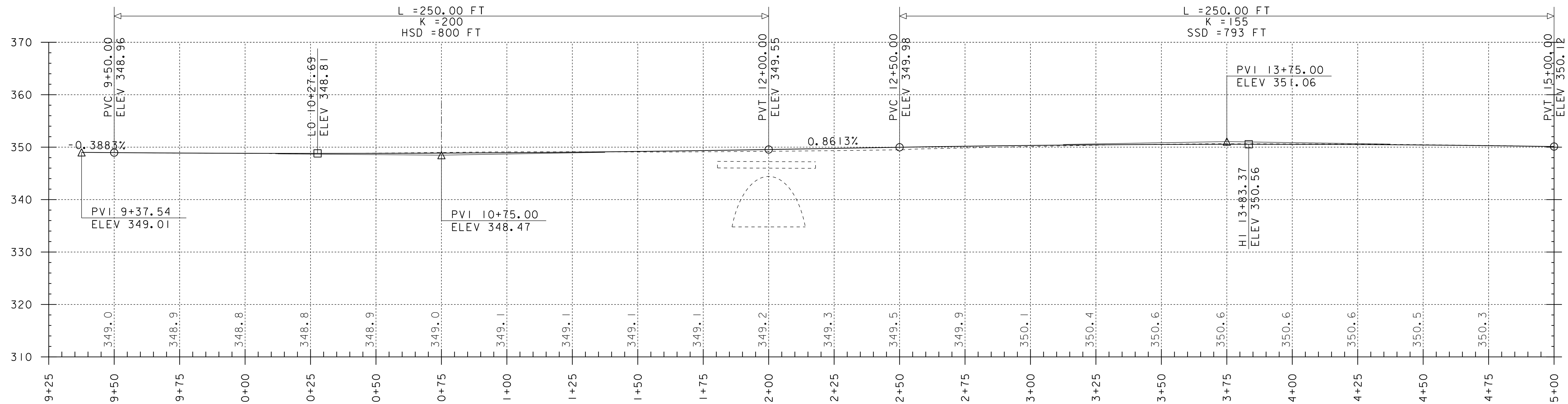
Appendix J: Plans

EXISTING BRIDGE DATA
28′-0" SPAN X 9′-7½" RISE CGMPPA
78′-0" LENGTH, BUILT 1972.
W/ 38′-0" X 26′-0" CONCRETE SLAB
BURIED OVER CULVERT IN 1998.
210 SQ-FT WATERWAY OPENING
BACKWATERS FROM OTTER CREEK.

RESOURCE SITE PLAN

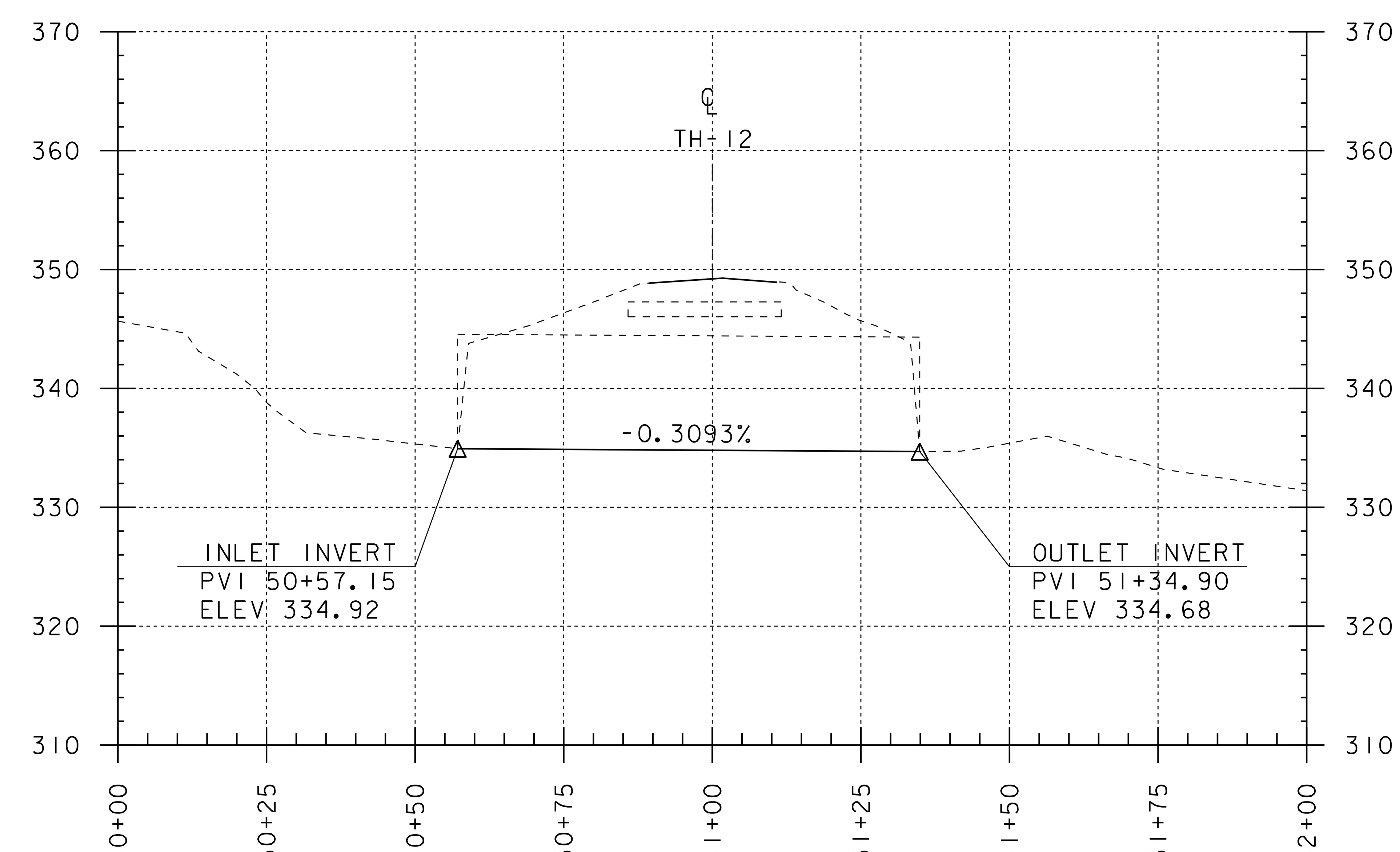
SCALE 1" = 20′-0"
20 0 20

PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636/s12j636border.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
RESOURCE SITE PLAN	SHEET 1 OF 15



TH 12 PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"



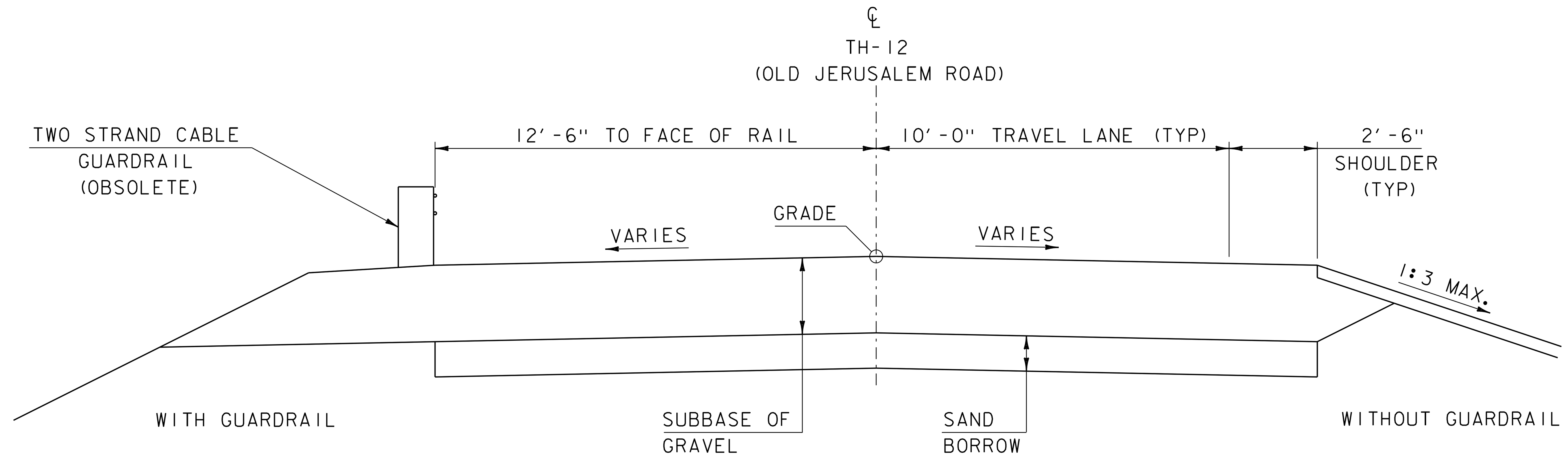
EXISTING CHANNEL PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"

NOTE:
GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG ℄
GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG ℄

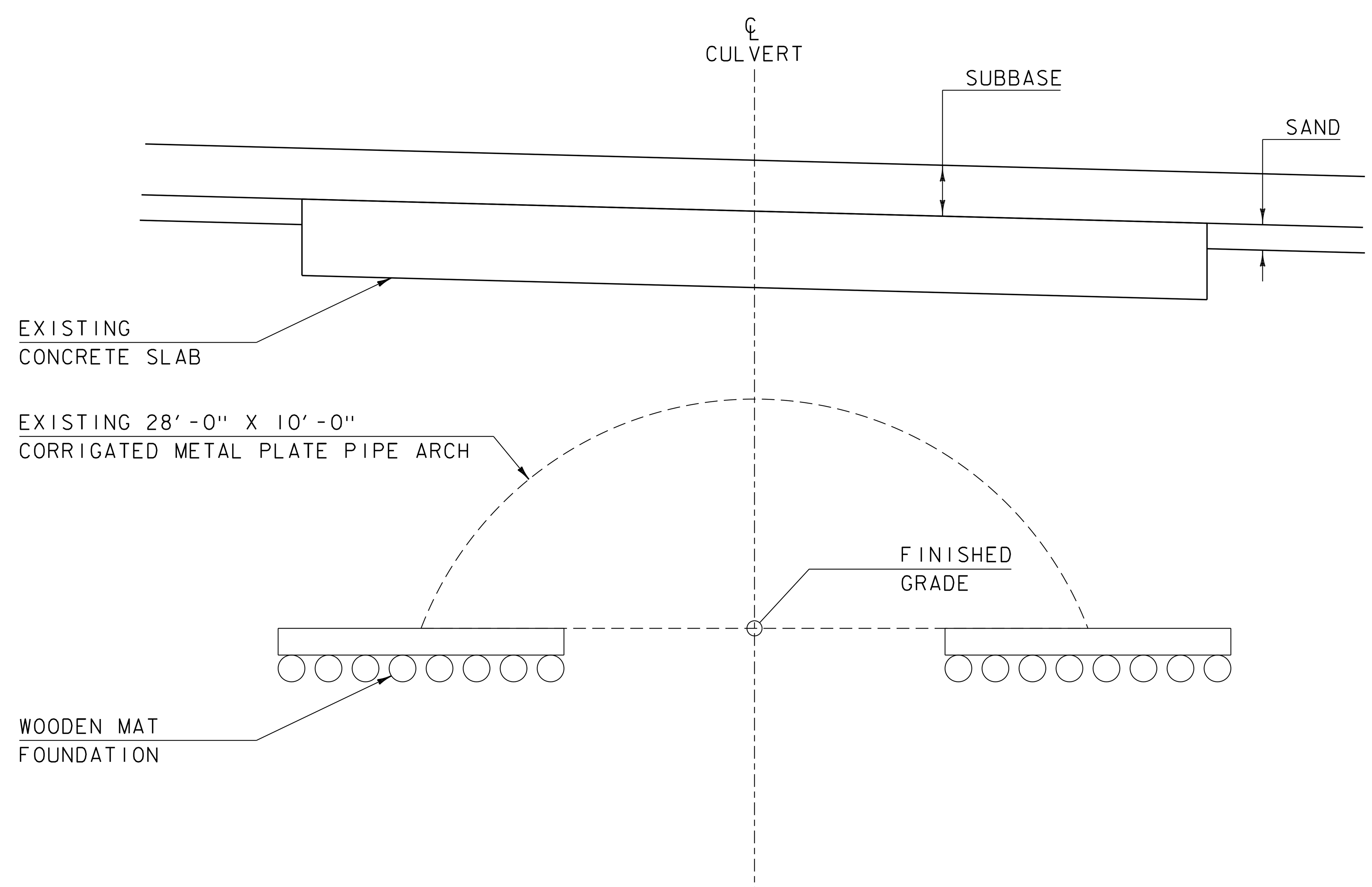
PROJECT NAME: LEICESTER
PROJECT NUMBER: BO 1445(37)

FILE NAME: 12j636/s12j636profile.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
PROFILE SHEET	SHEET 2 OF 15



EXISTING TH 12 TYPICAL SECTION

SCALE ⅜" = 1'-0"



EXISTING TYPICAL SECTION

NOT TO SCALE

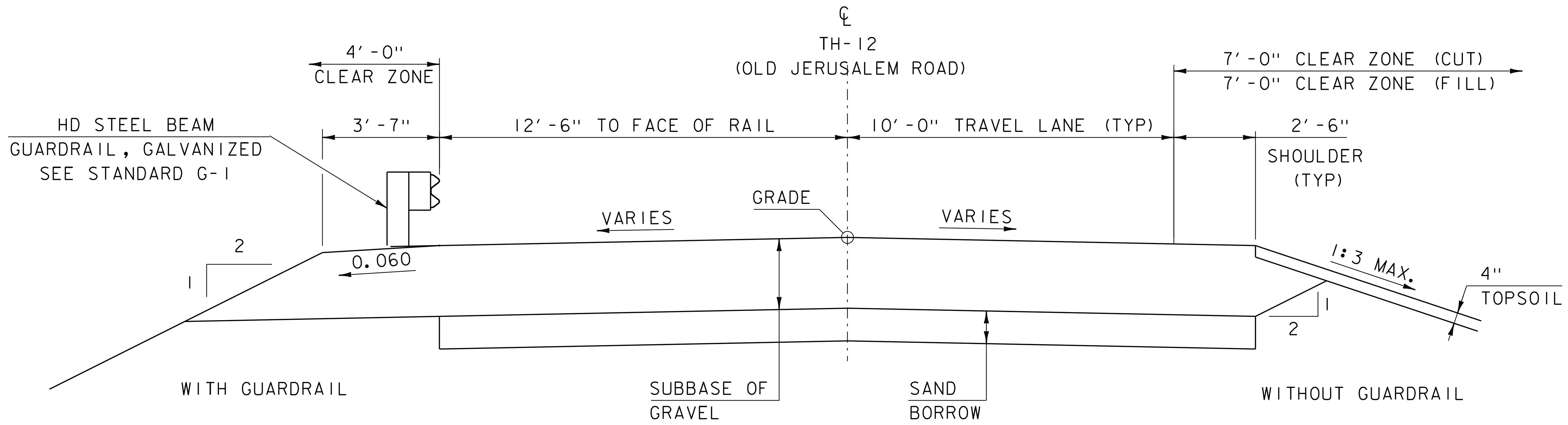
PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636\s12j636typical.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
EXISTING TYPICAL SECTIONS	SHEET 3 OF 15

ALTERNATIVE 2 LAYOUT

SCALE 1" = 20′-0"

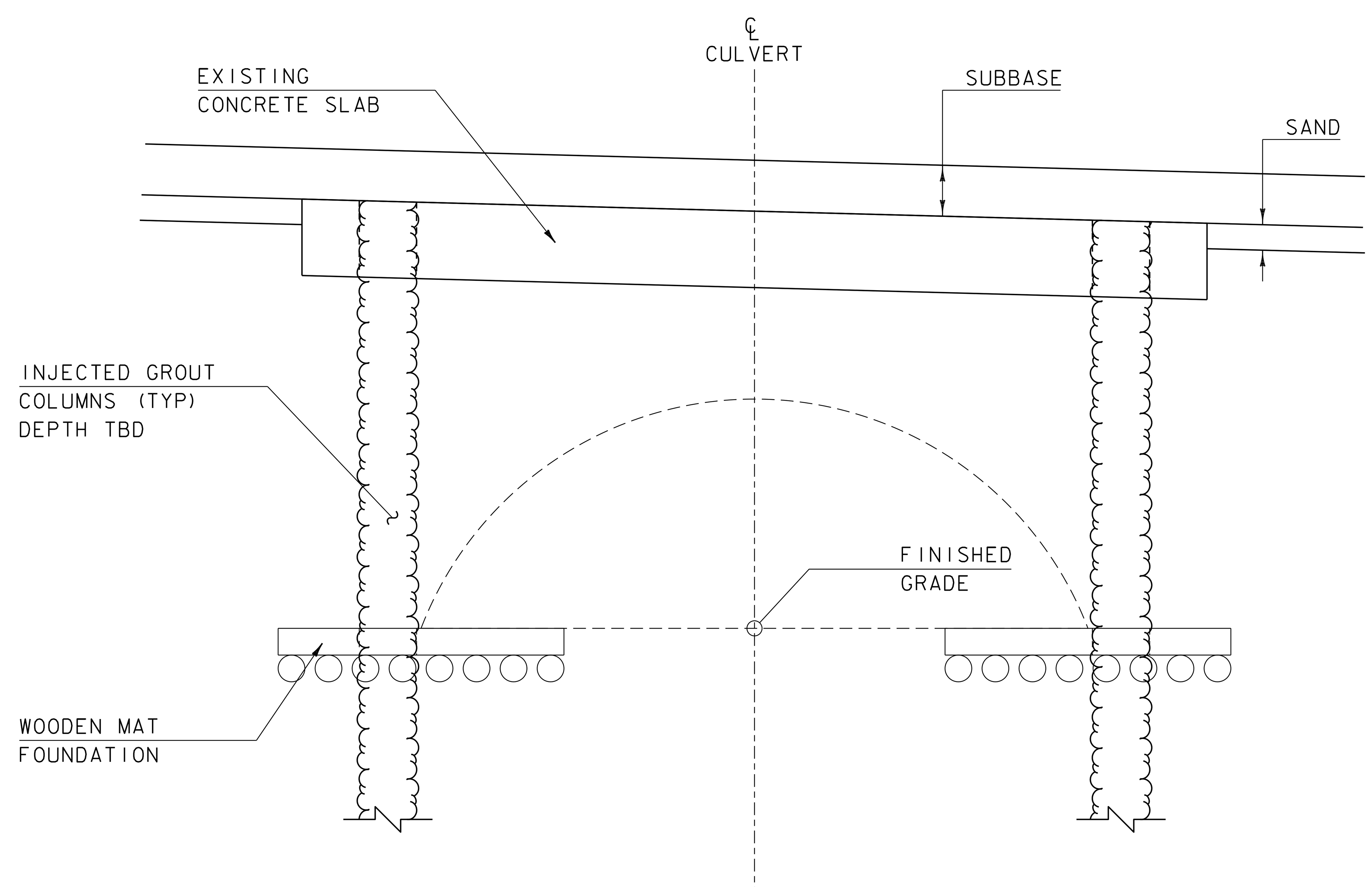
20 0 20

PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636/s12j636border.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
ALTERNATIVE 2 LAYOUT	SHEET 4 OF 15



PROPOSED TH 12 TYPICAL SECTION

SCALE 3/8" = 1'-0"



ALTERNATIVE #2 TYPICAL SECTION

NOT TO SCALE

PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636\sl2j636typical.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
ALTERNATIVE #2 TYPICAL SECTIONS	SHEET 5 OF 15

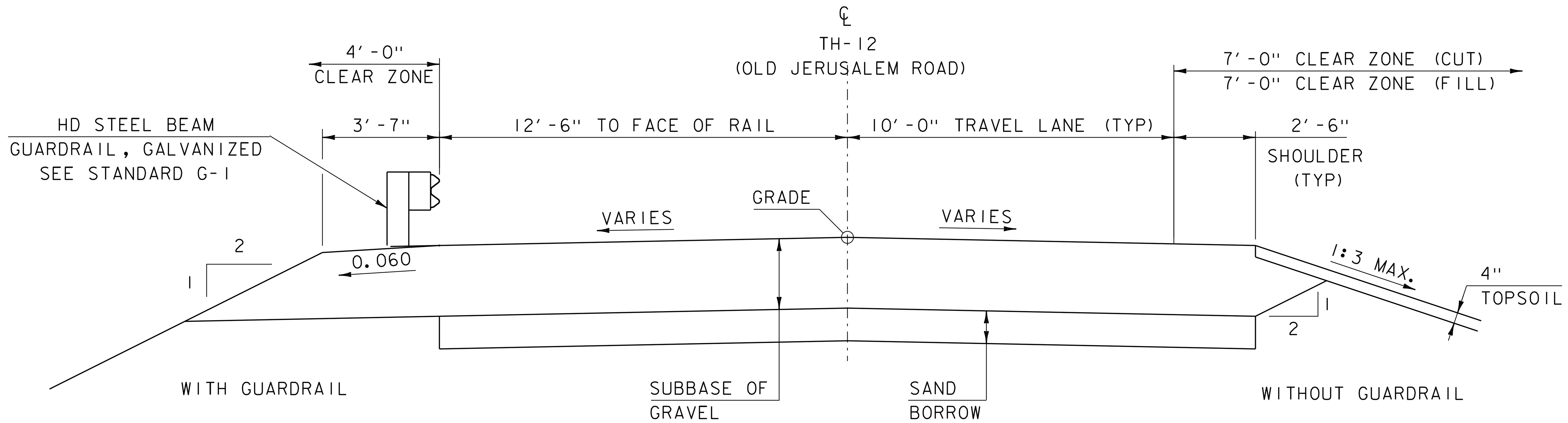
ALTERNATIVE 3 LAYOUT

SCALE 1" = 20′-0"
20 0 20

PROJECT NAME: LEICESTER
PROJECT NUMBER: BO 1445(37)

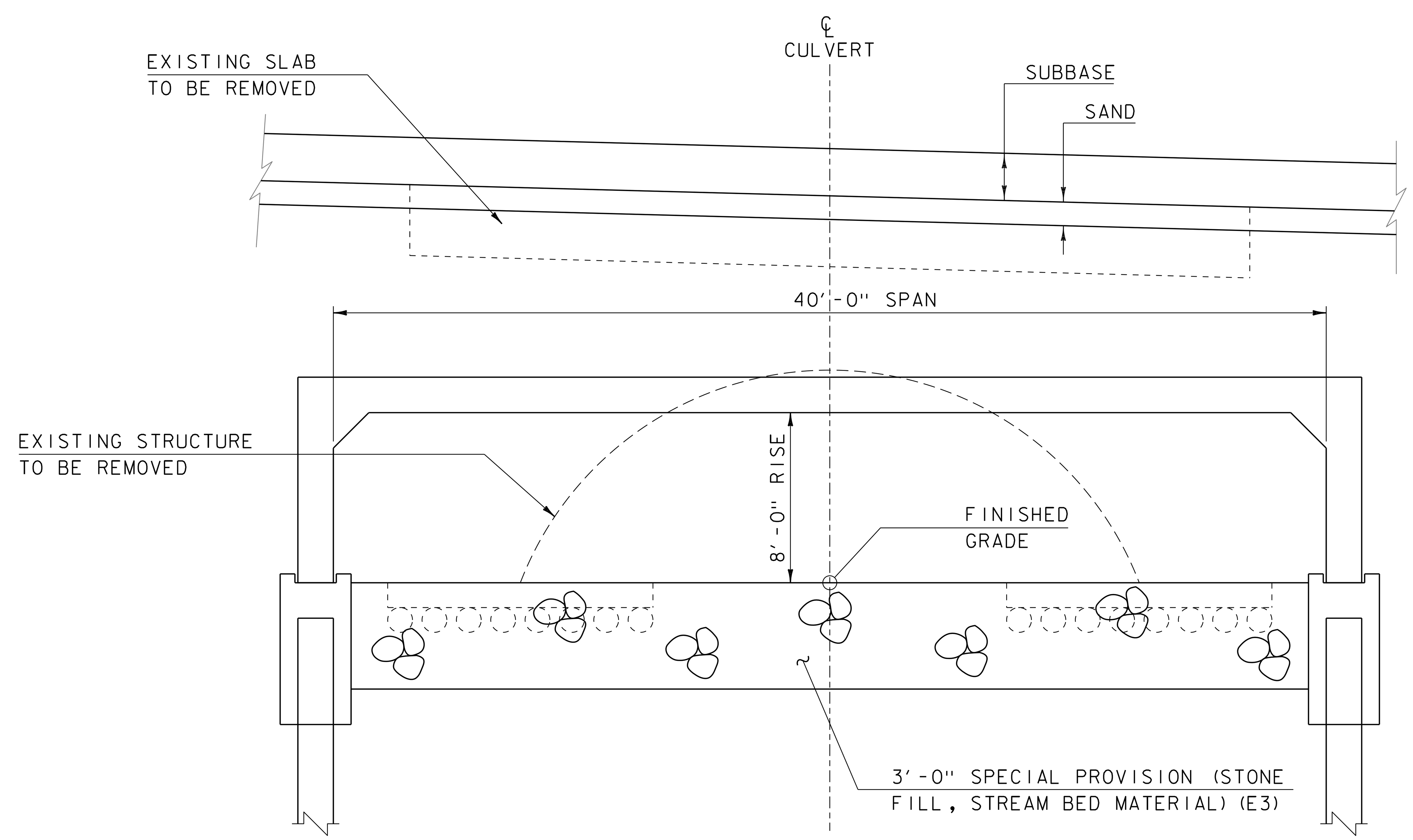
FILE NAME: 12j636/s12j636border.dgn
PROJECT LEADER: N.WARK
DESIGNED BY: G.SWEENY
ALTERNATIVE 3 LAYOUT

PLOT DATE: 08-AUG-2017
DRAWN BY: D.D.BEARD
CHECKED BY: G.SWEENY
SHEET 6 OF 15



PROPOSED TH 12 TYPICAL SECTION

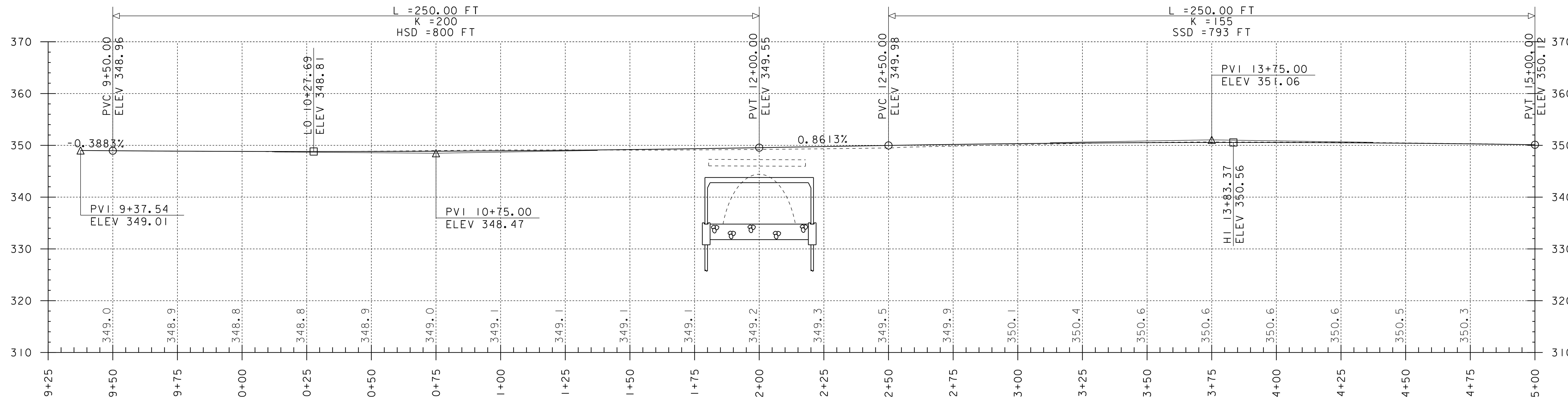
SCALE 3/8" = 1'-0"



ALTERNATIVE #3 TYPICAL SECTION

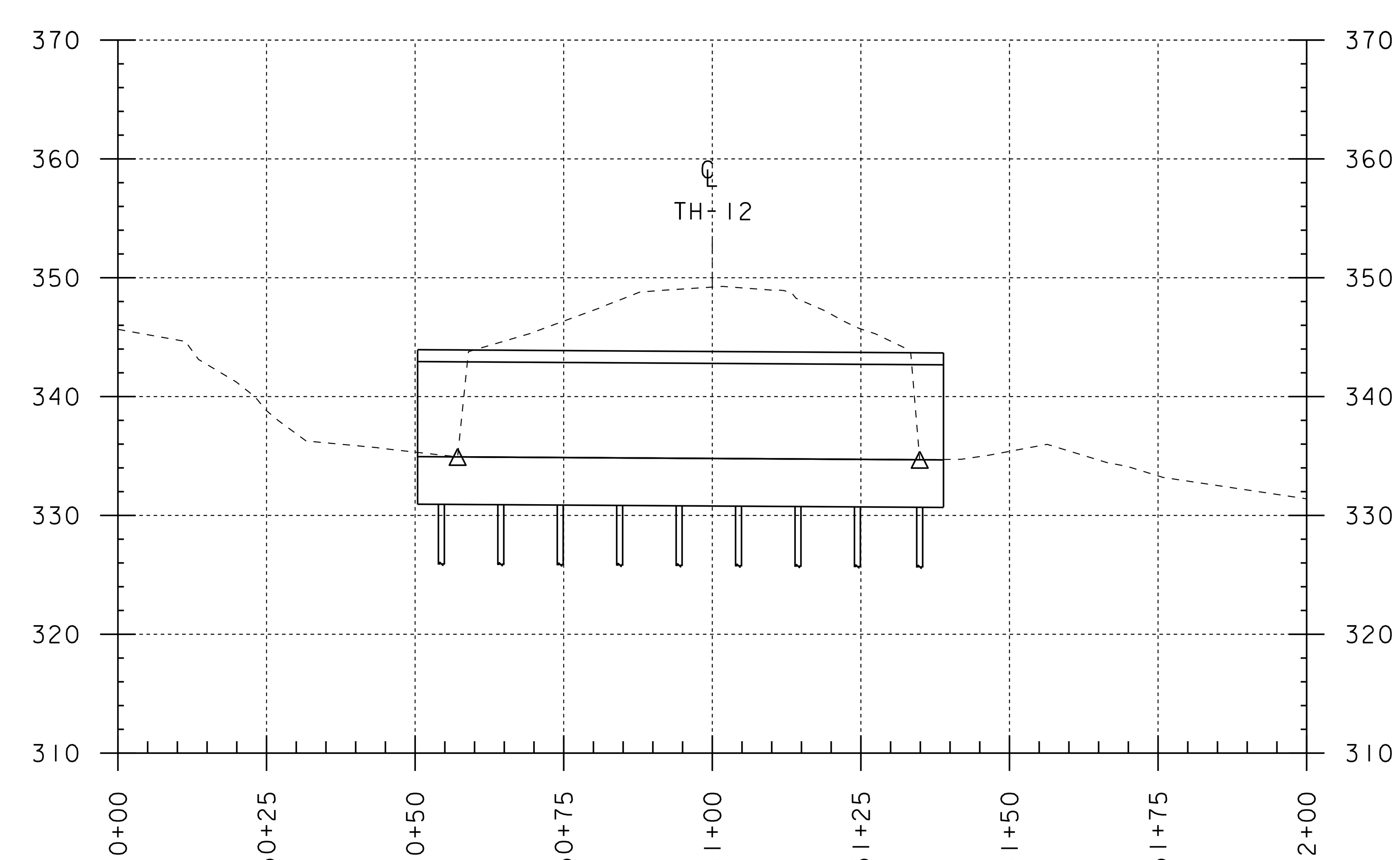
NOT TO SCALE

PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636\s12j636typical.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
ALTERNATIVE #3 TYPICAL SECTIONS	SHEET 7 OF 15



ALTERNATIVE 3 TH 12 PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"



ALTERNATIVE 3 CHANNEL PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"

NOTE:
GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG ℄
GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG ℄

PROJECT NAME: LEICESTER
PROJECT NUMBER: BO 1445(37)

FILE NAME: 12j636/sl2j636profile.dgn
PROJECT LEADER: N.WARK
DESIGNED BY: G.SWEENY
ALTERNATIVE #3 PROFILE SHEET

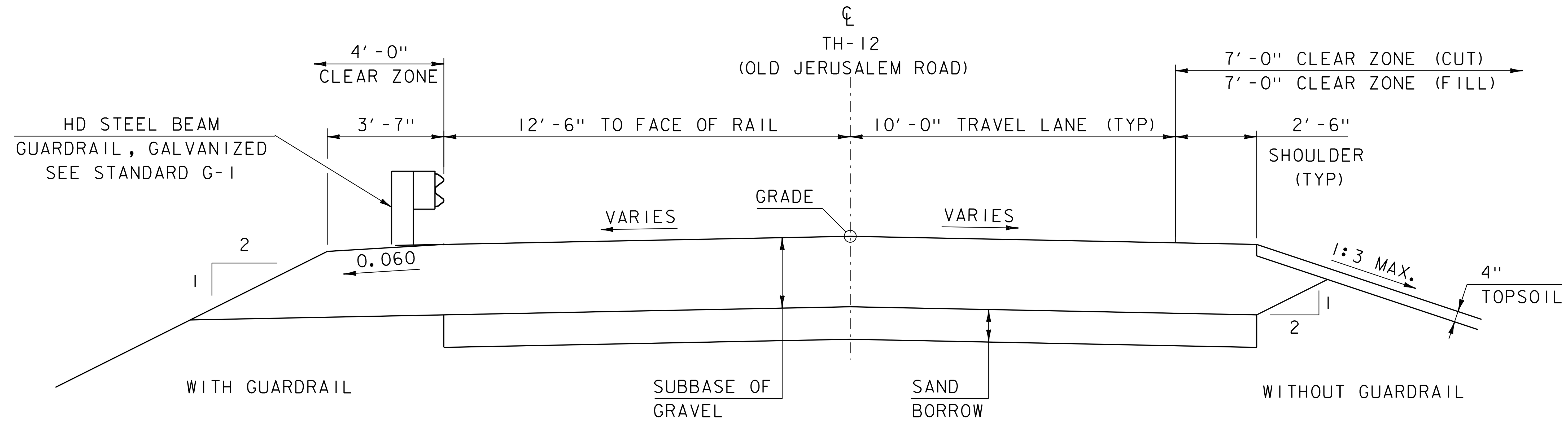
PLOT DATE: 08-AUG-2017
DRAWN BY: D.D.BEARD
CHECKED BY: G.SWEENY
SHEET 8 OF 15

ALTERNATIVE 4 LAYOUT

SCALE 1" = 20′-0"

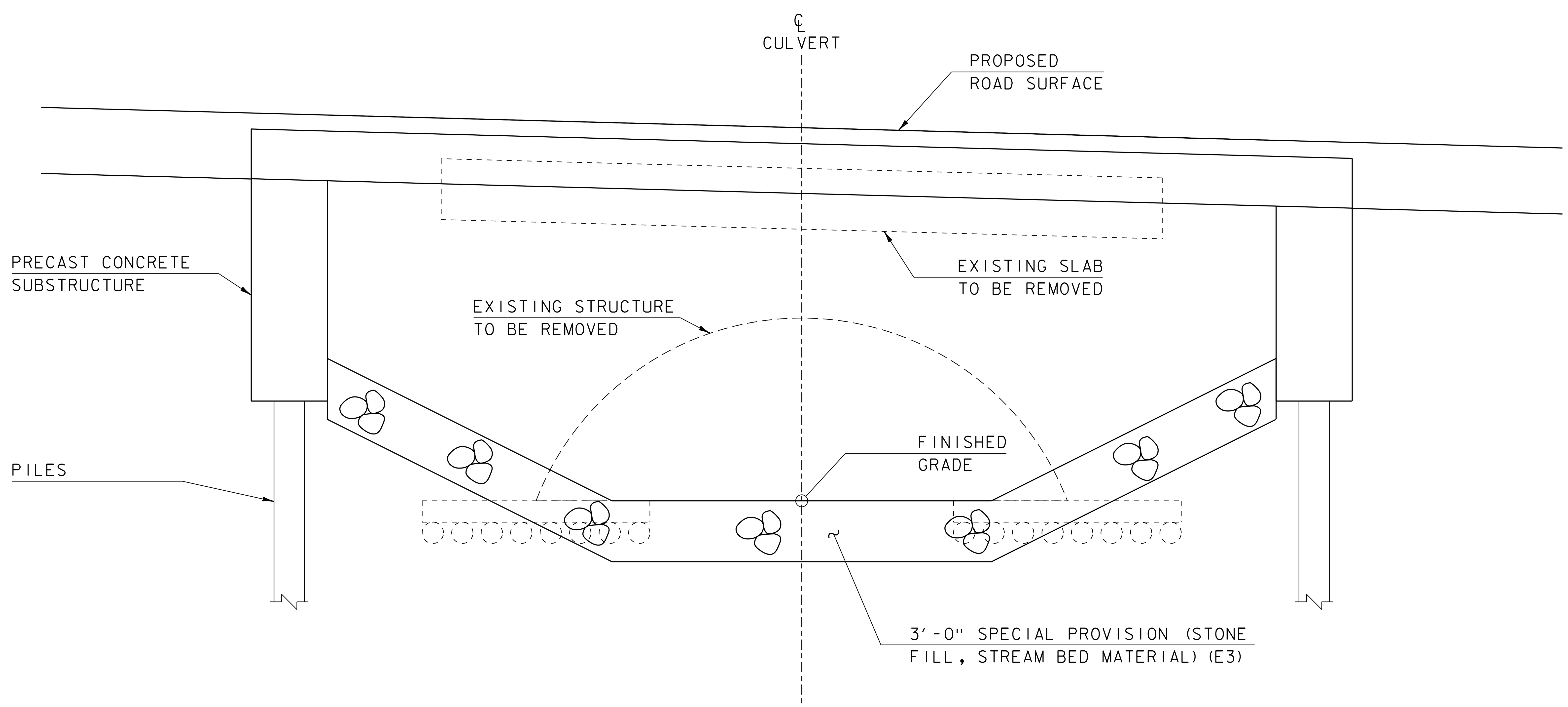
20 0 20

PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636/sl2j636border.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
ALTERNATIVE 4 LAYOUT	SHEET 9 OF 15



PROPOSED TH 12 TYPICAL SECTION

SCALE 3/8" = 1'-0"

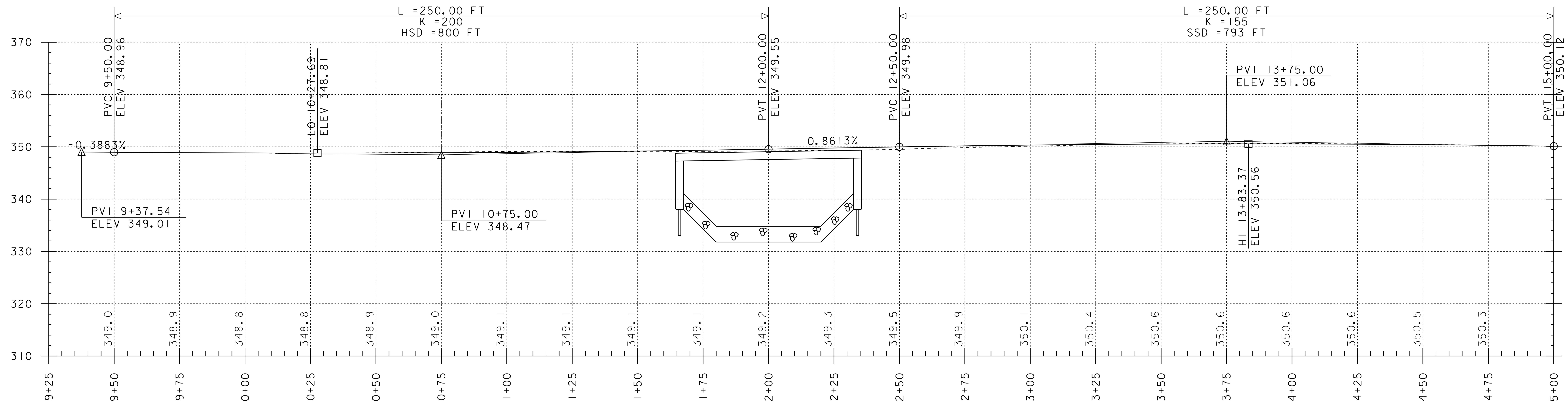


ALTERNATIVE #4 TYPICAL SECTION

NOT TO SCALE

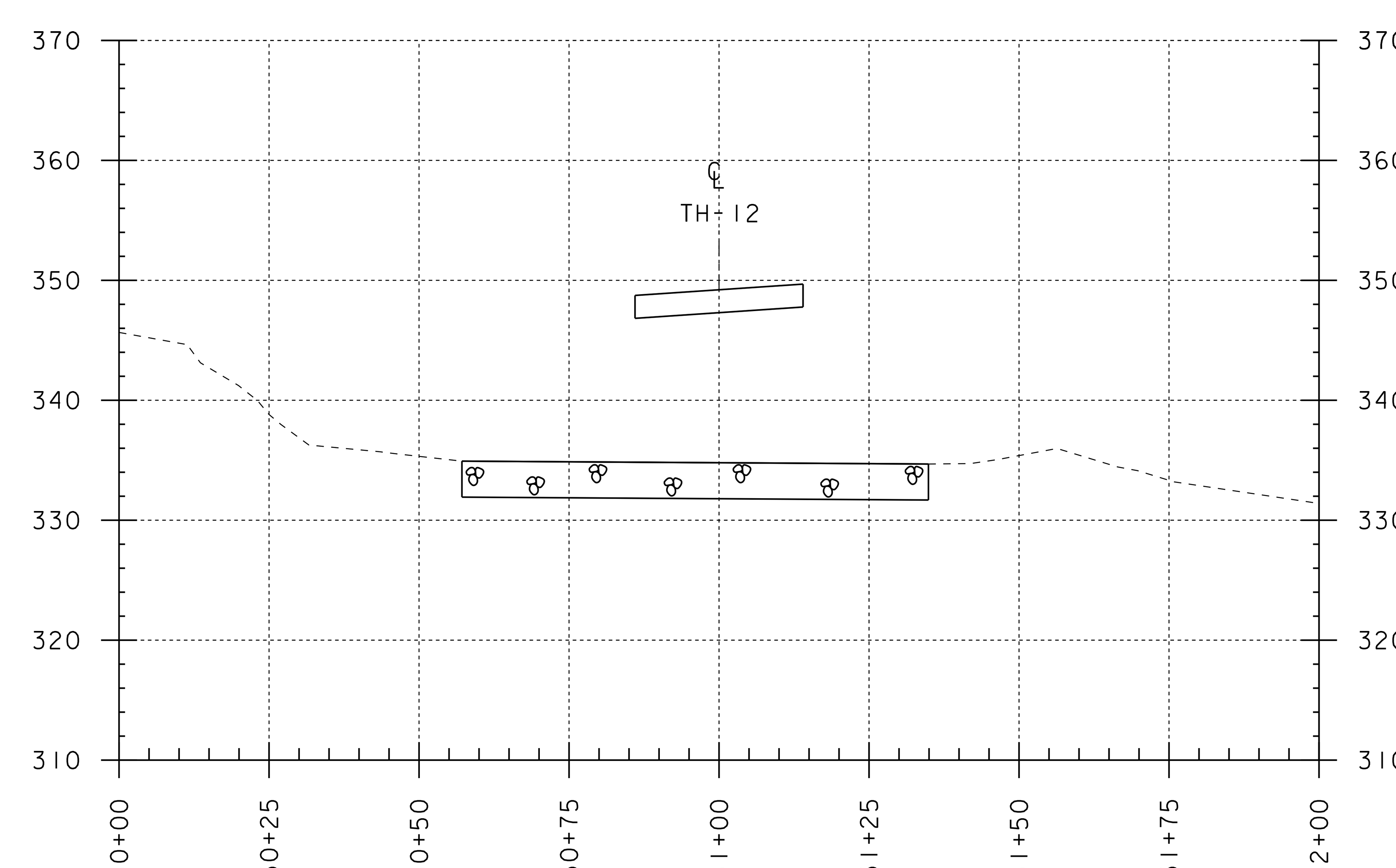
PROJECT NAME: LEICESTER
PROJECT NUMBER: BO 1445(37)

FILE NAME: 12j636\s12j636typical.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
ALTERNATIVE #4 TYPICAL SECTIONS	SHEET 10 OF 15



ALTERNATIVE 4 TH 12 PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"



ALTERNATIVE 4 CHANNEL PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"

NOTE:
GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG ℄
GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG ℄

PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636/sl2j636profile.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
ALTERNATIVE #4 PROFILE SHEET	SHEET 11 OF 15

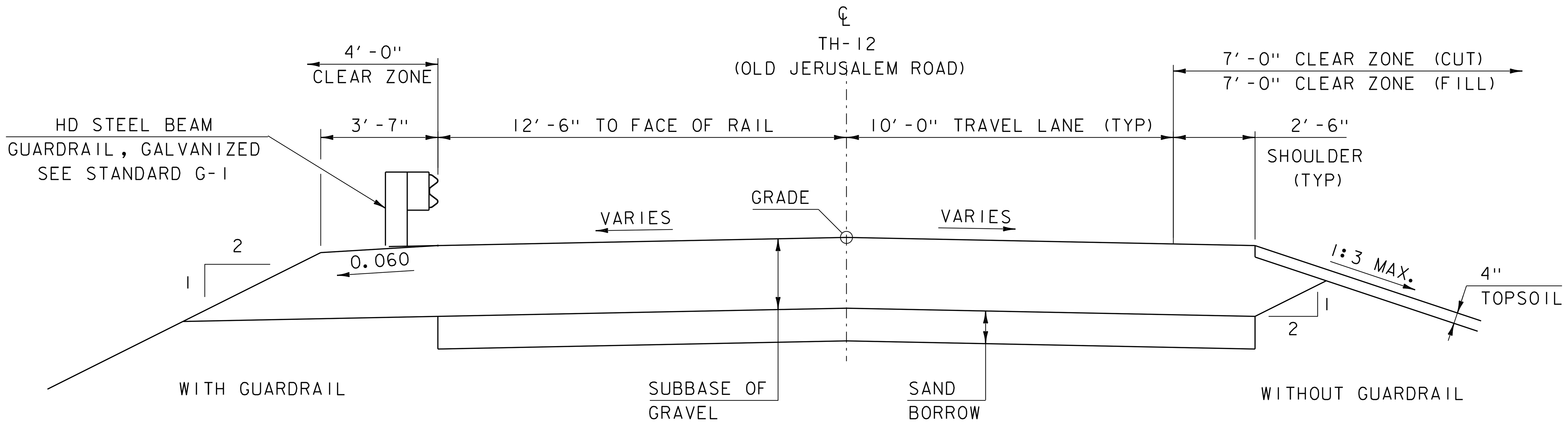
ALTERNATIVE 5 LAYOUT

SCALE 1" = 20′-0"
20 0 20

PROJECT NAME:	LEICESTER
PROJECT NUMBER:	BO 1445(37)

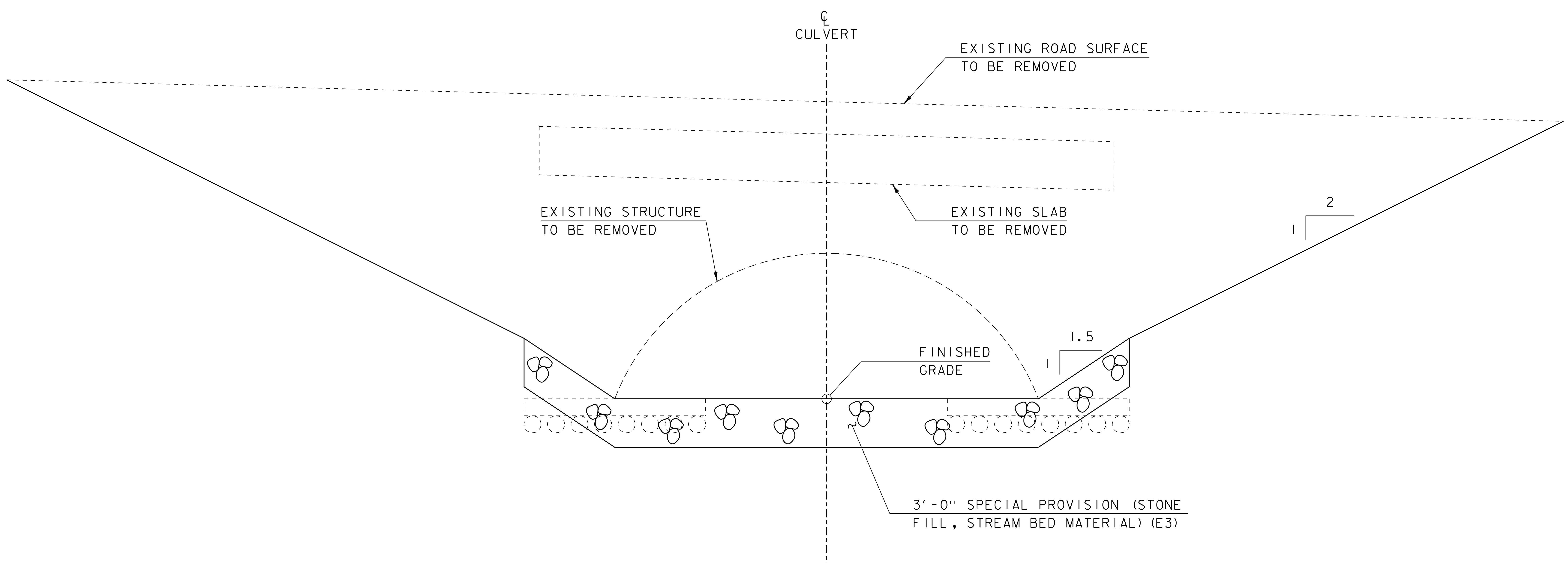
FILE NAME: 12j636/s12j636border.dgn
PROJECT LEADER: N.WARK
DESIGNED BY: G.SWEENY
ALTERNATIVE 5 LAYOUT

PLOT DATE: 08-AUG-2017
DRAWN BY: D.D.BEARD
CHECKED BY: G.SWEENY
SHEET 12 OF 15



PROPOSED TH 12 TYPICAL SECTION

SCALE ⅜" = 1'-0"



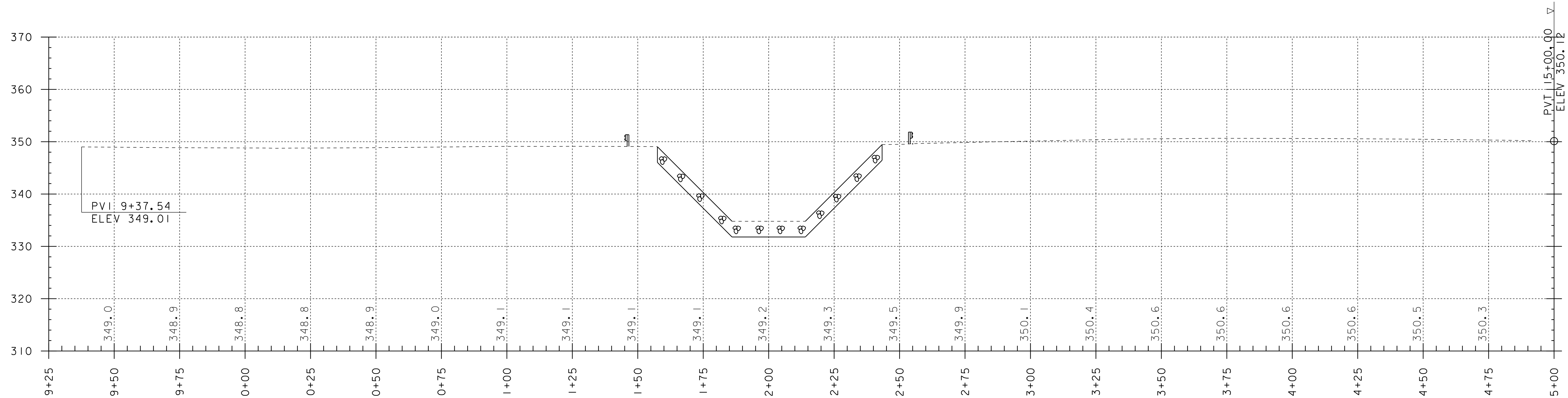
ALTERNATIVE #5 TYPICAL SECTION

NOT TO SCALE

PROJECT NAME: LEICESTER
PROJECT NUMBER: BO 1445(37)

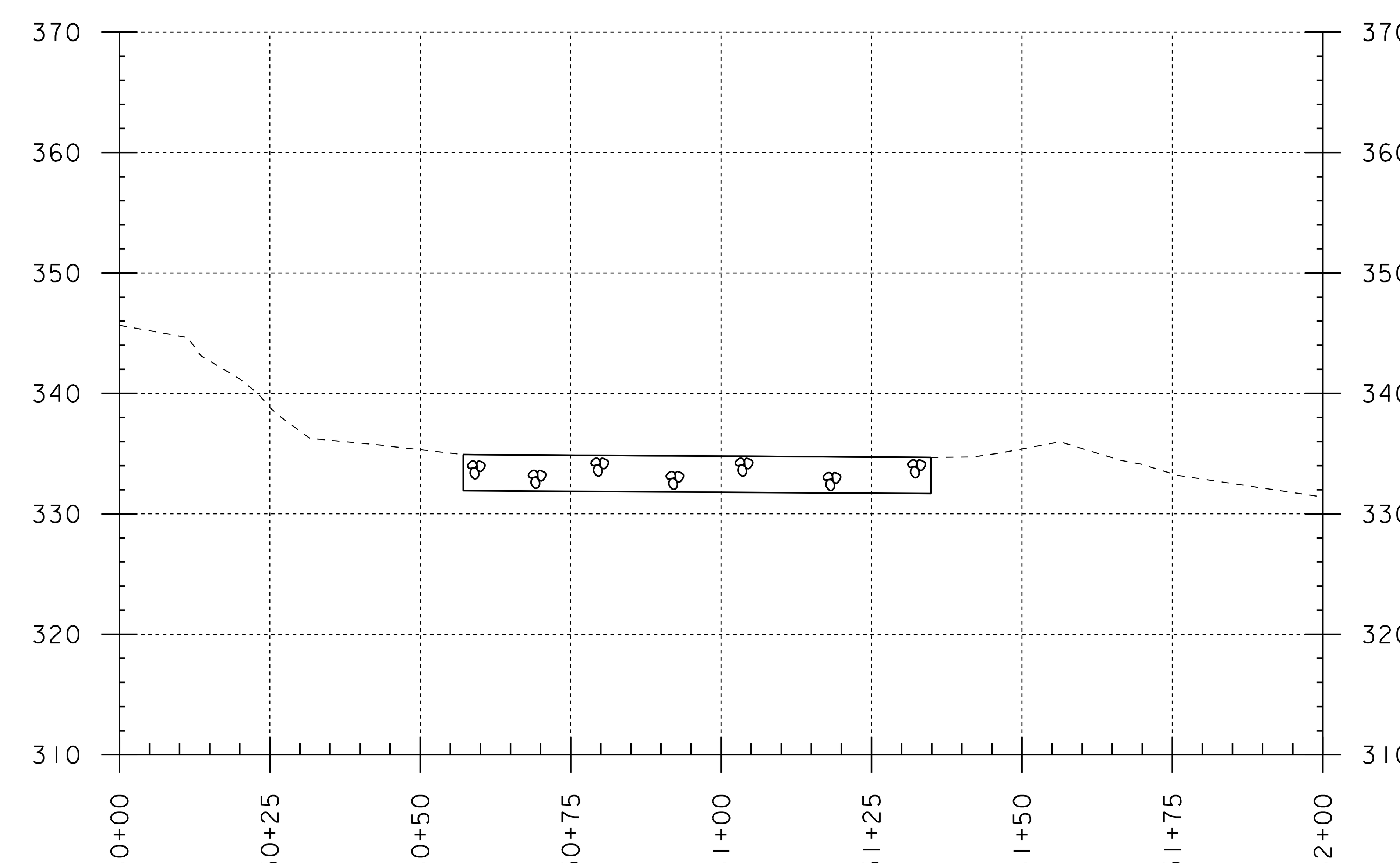
FILE NAME: 12j636\s12j636typical.dgn
PROJECT LEADER: N.WARK
DESIGNED BY: G.SWEENY
ALTERNATIVE #5 TYPICAL SECTIONS

PLOT DATE: 08-AUG-2017
DRAWN BY: D.D.BEARD
CHECKED BY: G.SWEENY
SHEET 13 OF 15



ALTERNATIVE 5 TH 12 PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"



ALTERNATIVE 5 CHANNEL PROFILE

SCALE: HORIZONTAL 1"=20'-0"
VERTICAL 1"=10'-0"

NOTE:
GRADES SHOWN TO THE NEAREST TENTH ARE EXISTING GROUND ALONG ℄
GRADES SHOWN TO THE NEAREST HUNDREDTH ARE FINISH GRADE ALONG ℄

PROJECT NAME: LEICESTER	
PROJECT NUMBER: BO 1445(37)	
FILE NAME: 12j636/s12j636profile.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
ALTERNATIVE #5 PROFILE SHEET	SHEET 14 OF 15

UPSTREAM TEMPORARY BRIDGE LAYOUT

SCALE 1" = 20′-0"
20 0 20

PROJECT NAME:	LEICESTER
PROJECT NUMBER:	BO 1445(37)

FILE NAME: 12j636/sl2j636border.dgn	PLOT DATE: 08-AUG-2017
PROJECT LEADER: N.WARK	DRAWN BY: D.D.BEARD
DESIGNED BY: G.SWEENY	CHECKED BY: G.SWEENY
UPSTREAM TEMP BRIDGE LAYOUT SHEET	SHEET 15 OF 15